March 23, 1951

THE ENGINEER

A Seven-Day Journal

Institution of Naval Architects Annual Dinner

The annual dinner of the Institution of Naval Architects was held in the Connaught Rooms, London, on Wednesday, March 14th, and was attended by a company numbering more than 700, with the President, Admiral of the Fleet, Viscount Cunningham, in the chair. His Excellency the French Ambassador proposed the toast of "The Institution of Naval Architects," and paid personal tribute to Viscount Cunningham for his sympathy towards France over the Alexandria incident. He also commended the part played by British shipyards in the reconstruction of the French merchant fleet. In his reply, the President welcomed the improved crew accommodation on board ship and made a plea for the preservation of a sense of proportion. In these days, he said, it was impossible to plan on a commercial basis and merchant ships must have latent in them certain fundamental qualities required by the Admiralty, especially improved safety against under-water damage and higher speed. Mentioning foreign competition, the President deplored the perpetual insistence on easier conditions and the demand for "rights" without any willingness to accept responsibilities. State control, he claimed, tended to induce the acceptance of the second-rate, with a consequent threat to the ability to compete with other countries. Continuing, the President expressed amazement at men indulging in petty recriminations and the acceptance of infantile demarcations of work. Passing on to the question of an international system of tonnage measurement, Viscount Cunningham recommended the formation of a working party and hoped that the work of the existing committee would result in an improvement of the present tonnage measurement laws, which had been called a "farrago of nonsense." Finally, the President called attention to the conditions of service in the Royal Corps of Naval Constructors and expressed perturbation at the present state of affairs.

Machine Tool Trades Association

Last Thursday, March 15th, the Machine Tool Trades Association returned to its pre-war practice and held an annual dinner instead of an annual lunch. Its president, Mr. J. B. S. Gabriel, took the chair and Sir Andrew Duncan was the guest of honour. Sir Andrew, in proposing the toast of the Association, referred to the successful participation of its members in the Toronto Trade Fair last year. After a long period of neglecting it, British machine tool makers were now re-entering the Canadian market. But, owing to the rearmament drive, the situation in this country to-day had become similar to that ruling in 1939, when defence production and "dollar" exports production needed to be combined. How problems of priority were to be settled to-day he did not know. But now that the Canadian market had again been entered, it would be irretrievably lost if it came once more to be neglected. For competing abroad, the machine tool trade had two advantages. It had preserved individuality amongst its firms, despite the necessity for a central organisation; and it enjoyed to-day a price for its raw material, steel, lower than that of its competitors abroad. That low price was the consequence of the development of a new type of co-operation between the industry and the Government. He felt, therefore, that it was a false step to nationalise the industry and he believed that measure would be repealed. In reply, Mr. Gabriel referred to criticisms that the machine tool industry had not responded rapidly enough and that it was expecting too much of its output. Despite these criticisms, he held that the machine tool population of this country was larger than it ever was before and that those tools were not fully used because shortage of labour and other difficulties prevented night shifts being worked. It was true that for the last few years demand had been running in excess of supply. But it had to be remembered that before the war demand was partly met by imports, whereas imports now were severely restricted. The toast of "Our Guests" was proposed by Mr. R. W. Asquith and replies by Mr. Keith Fraser, President, British Engineers Association, and Mr. S. W. Rawson, Director General, Machine Tools, Ministry of Supply, brought the proceedings to an end.

Derailment near Doncaster Railway Station

On Friday, March 16th, shortly after the 10.6 a.m. train from Doncaster to King's Cross left Doncaster Station, its third coach was derailed and struck one of the piers of Balby Bridge, about ½ mile south of the station. The train was not travelling very fast and the locomotive and the first two coaches, after crossing some points, passed safely under the bridge. Reports indicate that the third coach, however, was derailed at the points and was dragged some distance before it broke loose from the train. After breaking loose, the coach hit the pier of the bridge and part of it was torn away and entered the mouth of a tunnel leading down to locomotive sheds and sidings at the side of the bridge. The nine coaches which followed were also derailed and the lines to London south of Doncaster were blocked. We regret to record that, as a result of the accident, fourteen people were killed and twenty-three were injured.

The Orrin Hydro-Electric Scheme

The North of Scotland Hydro-Electric Board has now published details of the Orrin hydro-electric scheme (Constructional Scheme No. 29), which will develop the River Orrin, a south bank tributary of the River Conon, in Ross-shire, to produce 18MW of power and an annual output of 74,000,000 units of electricity. The Orrin project is the third stage of a group of schemes in the basin of the River Conon, the first stage of which, the Fannich scheme, went into operation in November, 1950; the second stage is the Glascarnoch-Luichart-Torr Achilty scheme, upon which work is just starting. The estimated cost of the Orrin scheme is £3,500,000 and the proposed works include a reservoir, to be formed in Glen Orrin, five miles upstream from the Orrin Falls, by the construction of a dam 120ft high and 972ft long across the river. The new loch will be fed from a catchment area of 54 square miles with an average rainfall of about 68in. From the reservoir water will be taken by a tunnel to the Orrin generating station in Strathconon, near Achonokie, and will be discharged into the reservoir, which will be formed by the Torr Achilty dam.

Knockshinnoch Castle Colliery Accident Report

The report has now been published, by H.M. Stationery Office, of Sir Andrew Bryan, Chief Inspector of Mines, on the accident which occurred at Knockshinnoch Castle Colliery, Ayrshire, on September 7, 1950. As a result of the disaster thirteen miners regrettably lost their lives and 116 others were trapped for a lengthy period. The Chief Inspector says that the accident was caused by an inrush of peat which broke through from the surface into the face of No. 5 heading in the South Boig district of the main coal seam on the night of September 7, 1950. The peat continued to flow for some time and soon filled up miles of underground roadways and blocked all means of exit from the underground workings to the surface. Although the position of the peat deposit was shown on the geological survey map of the district and the map had been consulted in the planning department, the symbol indicating the presence of peat in the field concerned in the disaster had been overlooked. The report suggests that there was a weakness in organisation in that insufficient arrangements were made to ensure that the planning engineers were kept adequately informed of the subsequent changes disclosed by the progress of the workings in the No. 5 heading section to enable them to check the accuracy of the forecasts in the development plan for that district of the mine, which was made in April, 1950. As a result of his inquiry, the Chief Inspector recommends that no working should approach within 150ft of the surface until the nature of the intervening ground between the surface and the expected horizon of the proposed working has been determined by boring or other approved means. Among other recommendations made in the report are that research should be started to explore the possibilities of a rapid and accurate geophysical or other method of surveying to determine the thickness, nature and extent of all unconsolidated superficial deposits; that the provision of some form of simple, light-weight, self-contained breathing apparatus which could be worn by any workman, after minimum instruction, should be investigated without delay; that, where practicable, the provision of an "escape" roadway giving direct access to an adjacent mine should be considered, and that consideration should be given to the provision of a telephone cable for underground use in mines which will be highly resistant to damage from inrush, inundation or fire.

The Science Museum

Particulars have been given this week of developments at the Science Museum, South Kensington, which are taking place in connection with the Festival of Britain. Building operations which are now in progress will enable five sections of the permanent collections either to be opened for the first time or reopened in completely modernised form. They are:—Chemistry, atomic physics, mining, agricultural machinery and gas manufacture. There is also being prepared a temporary exhibition entitled "The Science Museum: Past and Future," which will show the birth and development of the Museum during the past century and its expansion in the near future. A central historical exhibit will show by prints, documents and photographs how the Science Museum began nearly one hundred years ago, how it has grown, and what it is hoped it will eventually become. To illustrate its future expansion, a selection will be shown from those collections which cannot at present be put on general view on account of lack of space. Among the selection there will be part of the King George III collection of eighteenth-century scientific instruments, and exhibits will also be selected from collections dealing with civil engineering, mechanical power transmission and seismography, and a series of models depicting the evolution of fire-fighting methods.

Vibration Test Equipment for Turbine Blades

By A. M. ROBERTS, B.Sc., Wh.Ex., and A. A. GREGORY.

IN order to assist turbine engineers in their endeavours to avoid troubles which may result from blade vibration, it has, for many years, been the practice of the turbine department of Metropolitan-Vickers Electrical Company, Ltd., to have laboratory measurements made of the fundamental frequency of all new types of turbine blades, both singly and in packets, when resonated as cantilevers with the roots fixed in a similar manner to the service conditions. To meet this need electronic valve operated apparatus was developed in 1923 by the company's research department, following the basic principle of the electric bell, by which turbine blades could be readily maintained in vibration at their fundamental frequency, generally quite satisfactorily up to 600–700 c/s and with some difficulty up to 1000 c/s.

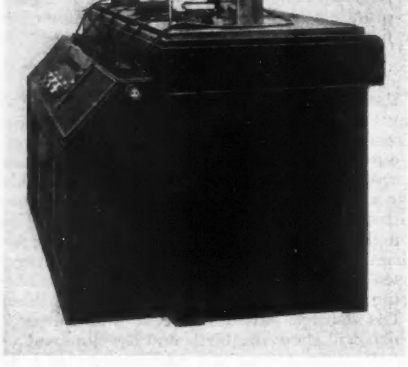
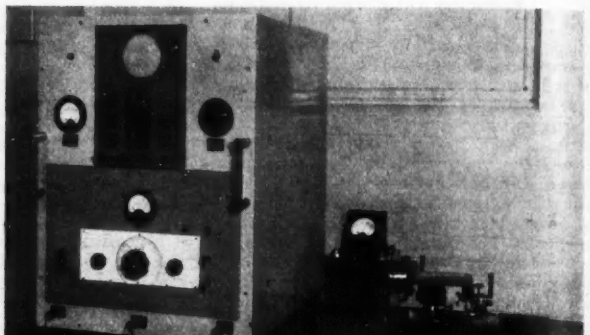


FIG. 3—IMPROVED TEST SET

The final developed form of this early equipment is shown by the photograph, Fig. 1, and a somewhat later and more powerful set, capable of carrying out fatigue tests on certain types of turbine blades, is shown by Figs. 3 and 4. With this apparatus it was, normally, only possible to measure the fundamental frequency of blades about the axis of minimum inertia and only a few of the higher harmonics or other modes of vibration could be excited under specially arranged conditions. In certain of the simpler forms of blade, calculated values for some of the higher modes could also be deduced from the measured fundamental frequency.

These limitations, however, were not generally regarded as being very troublesome with steam turbine blades because experience had indicated that the fundamental mode of vibration was, above all others, the one which it was most desirable to avoid. At the same time the need to explore further and to investigate the complete range of possible modes of vibration between defined frequency limits was becoming increasingly felt and, finally, led during 1943 to the development of new equipment easily capable of exciting all modes of vibration and measuring the corresponding frequencies up to the limit of audible sound and, when necessary, even beyond this range. Parallel with this development, equipment and technique have also been devised for quickly investigating the various modes of vibration assumed by the turbine blades when resonating at the higher frequencies.

The scope of the present article is confined to a description of the company's latest blade-testing apparatus, with particulars relating to its use in the determination of critical frequencies and modes of vibration, together with some notes on the character of the repeated magnetic impulse employed to promote vibration during the test.



FIGS. 1 AND 2—EARLY AND PRESENT-DAY FORMS OF VIBRATION TEST EQUIPMENT

APPARATUS

A general arrangement view of the present equipment, as set up for the testing of a gas turbine blade, is shown by Fig. 2 It consists of two main items: first, a valve oscillator coupled to a double beam oscillograph and its associated amplifiers, all built together into the cube-shaped unit on the left of Fig. 2, and, secondly, the blade holder mounted on a heavy cast iron base carrying the exciter magnet with a crystal microphone pick-up and an external resonance indicator, which are shown on the right of Fig. 2 and, to an enlarged scale, by Fig. 5.

The block arrangement of the connections between the different components is shown in Fig. 6. In this diagram the oscillator provides the primary source of the electrical oscillations employed to vibrate the turbine blade. The power available from the oscillator is, however, not sufficient in itself to drive the electro-magnet, hence the use of a power amplifier, the output from which is passed on to the electro-magnet.

The oscillograph, which is a standard double-beam instrument, is used principally as a "comparator" between the electrical frequency of the oscillator and the mechanical vibration of the blade. For this reason a tapping from the output of the oscillator is fed to the deflector terminal of one beam, Y_2 in this case and the output from the microphone is fed via a voltage amplifier built into the oscillograph and on to the deflector terminal Y_1 of the second beam.

The microphone is of the crystal type in order to avoid magnetic pick-up from the exciting magnet when these units are operating close together, as must be the case with short blades. Its purpose is to convert into electrical oscillations the sound emitted by the vibrating blade. The amplitude of the electrical oscillations from the microphone gives an approximate indication of the amplitude of the mechanical oscillations of the blade. During a steady increase or decrease in the oscillator frequency, resonances are indicated by sharp increases in amplitude on the Y_1 beam.

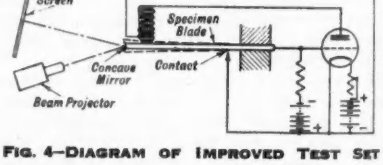


FIG. 4—DIAGRAM OF IMPROVED TEST SET

The function of the valve voltmeter is to convert the amplified microphone oscillations appearing on beam Y_1 into a d.c. potential, which gives an indication of the amplitude of these oscillations when applied to two pointer instruments in series, designated resonance indicators, one being mounted on the panel of the main unit and the other being in a portable form, linked up by flexible leads to the main unit. Of these two, the panel mounted instrument is used mainly for accurate tuning of the resonant frequencies, as it is considerably easier to read a maximum on a pointer instrument

than on a cathode-ray oscillograph. The use of the portable instrument is referred to later in the article. It should be noted that although the readings of the resonance indicators give an approximate measure of the sound emitted by the vibrating blade and therefore of the amplitude of the vibration, no claim is made that these instruments provide an accurate measure of amplitude. They do, however, give a clear-cut indication of the resonating point, which is all that is required for the purpose of the test.

The function of the equipment as a whole is two-fold: it permits the detection and measurement of resonant frequencies and it enables the operator to trace the nodal pattern for each resonant condition.

Detection of Resonant Frequencies

The blade under test is gripped by its root in a similar manner to the service conditions, as shown by Fig. 8. The electro-magnet is then placed under the tip of the blade with its pole faces as close as possible to the blade, whilst avoiding actual contact when the blade is in vibration. The microphone is also placed underneath the blade in order to leave the upper surface clear for the investigation of the mode of vibration described in the following section.

It may be noted in passing that the core and pole-pieces of the electro-magnet are made from soft iron, which means that two magnetic cycles will be exerted for every electrical cycle of the oscillator. This and other points relating to the character of the magnetic impulses are dealt with at greater length in the final section of the present article.

The required frequency range is then scanned slowly and at the same time the Y_1 beam is observed. Every resonance in the blade will result in a sudden increase in the amplitude of this trace. At each resonance a note is made of the oscillator frequency as read on the dial and of the frequency relationship between the exciting signal and the blade frequency, which, as stated in the previous paragraph, will generally be in the ratio of 1 to 2. Exceptions, which are discussed later, do arise, however, particularly with modes that are readily excited, when additional ratios of 1 to 1, 1 to 3, 1 to 4, &c., can be encountered. These are usually ignored and only the

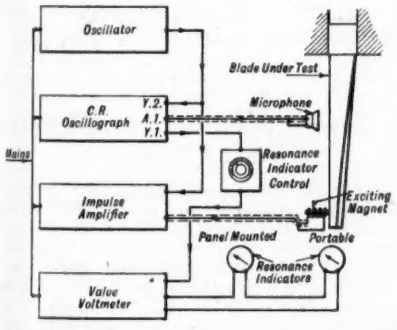
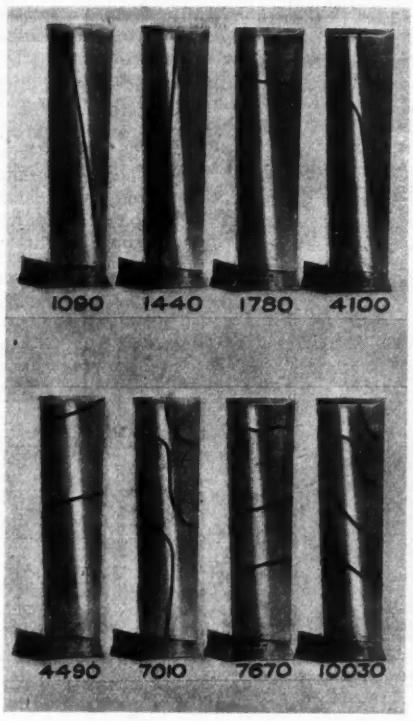


Fig. 5—Block Diagram of Test Equipment

oscillator frequencies associated with the 1 to 2 ratios are noted. The recorded oscillator readings, multiplied by 2 will then provide a list of the resonant blade frequencies within the range under investigation.

Tracing Nodal Patterns

With the list of resonant blade frequencies available, it is then necessary for complete information, to examine the corresponding modes of vibration, the procedure being as follows: the oscillator is set in turn to the various resonant frequencies, i.e., at half the actual blade frequency under examination. Fine tuning is completed by observation of the amplitude of trace Y_1 or, more accurately, with the aid of the resonance indicator mounted on the panel. A light (wood encased) pencil-point is then traversed firmly but not heavily over the surface of the vibrating blade. At any but a nodal



The patterns were determined at the resonant frequencies in cycles per second shown under each blade.

Fig. 6—Typical Nodal Patterns

position this will cause damping of the vibration and the reading on both resonance indicators will fall. The pencil-point is moved to scan the whole surface of the blade, axially as well as transversely, and a mark is made wherever the indicators register a maximum deflection. When the scanning is complete the series of marks joined together will trace out the nodal lines. Fig. 6 illustrates some typical nodal patterns obtained at different frequencies with the same blade.

A pencil-point is preferred for the above operation because the self-lubrication of the graphite as the point is moved along eliminates any grating and scratching which would otherwise make it difficult to distinguish the main note given out by the oscillation of the blade. The external resonance indicator, conveniently placed, is used for this purpose in order to facilitate the manipulation of the pencil whilst keeping watch on the resonance indicator. Employment of fine sand or other powder to indicate the nodal patterns is found to be impracticable on the curved surfaces of turbine blades.

The use of the equipment is not limited to blades made from magnetic materials, although these latter are more easily investigated. It is, in fact, often found that the eddy current field set up in a non-magnetic material will react with the imposed magnetic field so as to create conditions similar to those of a magnetic blade. In other cases, which do not react in this way, a very thin sliver of magnetic material may be glued to the blade to provide an armature. The mass of the attachment is usually so small that it has little or no effect on the resonant frequency and can generally be neglected. For those cases where the added mass cannot be ignored, additional measurements of frequency with attachments of two or three different masses can be made and the plotted results of "frequency" against "added mass," extrapolated to give the frequency for zero mass. The frequency characteristics of the microphone and other links in the electrical chain are regarded as unimportant and no difficulty has ever been experienced from this cause. Finally, it has been found that the position of the exciting electro-magnet on the blade is not critical as its two poles act over a comparatively large area and it is most unlikely that the chosen position would span exactly across a node and fail to produce resonance, although, theoretically, this condition appears to be possible.

Directional Determination

The suppression of a resonant condition by means of a pencil-point when determining the mode of vibration is most pronounced when the axis of the pencil lies in the direction of the motion. Because of the lubricating properties of the graphite, any motion perpendicular to the pencil axis is only affected to a minor degree and unless care is taken, it is therefore possible to confuse a stationary node with a region in which the vibration is at right-angles to the pencil axis. As a case in point, it would be difficult by means of the pencil test on a turbine blade to discriminate between (*a*) simple torsional vibration and (*b*) vibration as a cantilever parallel to the axis of minimum inertia, as both types of vibration respond in the same way to the application of a pencil-point.

In order to meet this and similar difficulties a device has been constructed to check the direction of motion in the few cases where the pencil test leaves some doubt. The device, shown by the photograph, Fig. 7, consists of a crystal type gramophone pick-up, which has marked directional response. This has been mounted

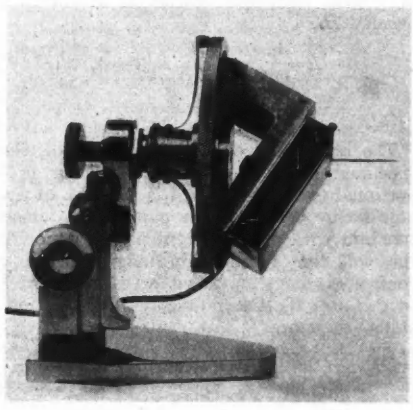


Fig. 7—Pick-Up for Directional Determinations

in such a manner that it can be adjusted by rotation about an axis coincident with that of a long, flexible pick-up needle.

When a case of vibration occurs in which the direction of motion is doubtful, the needle point is brought to bear against a suitable position on the vibrating object. The signal from the pick-up is then trans-

mitted, via an amplifier, to an oscillograph. On rotating the pick-up, the amplitude of the vibration record on the oscillograph will vary between minimum and maximum values; the latter value indicating the direction of the vibration by reference to the known properties of the pick-up. By this means, used in conjunction with a pencil, it is possible to determine the exact mode of any vibration where doubt exists.

Character of the Impulse

During a vibration test the amplified sinusoidal signal $E \sin 2\pi ft$ from the oscillator is delivered to the coil of the small exciting magnet. By checking the voltage variation across a small non-inductive resistance in series with this electro-magnet the character of the alternating current passing through the windings can be examined on an oscillograph.

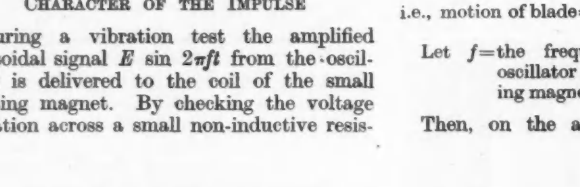


Fig. 8—Blade Holder, Exciter Magnet and Microphone

This (as can be shown from theoretical considerations) is found, in practice, to be very closely a true sine wave, $I \sin (2\pi ft - \alpha)$, and might therefore be expected, apart from the approach to saturation, and hysteresis in the core, to produce a correspondingly true sinusoidal variation in the flux density B.

$$B = \frac{4\pi n\mu}{10} \cdot I \sin (2\pi ft - \alpha),$$

$$\text{where } I = \frac{E}{\sqrt{R^2 + (2\pi f)^2 L^2}}.$$

The actual pull P of the magnet on the specimen can be expressed as being proportional to B^2A, where A is the area of the pole face. When the air gap is maintained constant with direct current passing through the coil this relationship may be readily confirmed by test, using a magnetometer to measure B. Combining the two relationships, therefore,

$$\text{Magnetic pull } P \propto B^2 \propto I^2 \sin^2 (2\pi ft - \alpha)$$
$$\propto \tfrac{1}{2} I^2 \{1 - \cos (4\pi ft - 2\alpha)\} . \quad (1)$$

From the above simple theory it will be seen that the resulting oscillation of the specimen takes place under the influence of an alternating force proportional to $\frac{1}{2}I^2 \cos (4\pi ft - 2\alpha)$ about a mean deflected position proportional to, and represented by, $\frac{1}{2}I^2$ and resonances of the specimen should therefore occur at twice the frequency of the oscillator signal. As the theoretical analysis given above shows that under the idealised conditions assumed there are no harmonics in the expression for the magnetic pull, it will be evident that any harmonic variations found in the magnetic force are most probably introduced by departures from the assumed conditions, such as may occur due to hysteresis and saturation in the magnet core or variation in the air gap during vibration of the specimen.

Let F = the frequency of the vibration of any particular mode in the blade,

i.e., motion of blade $= A \sin 2\pi Ft$ . . . (2)

Let f = the frequency (variable) of the oscillator e.m.f. supplied to the exciting magnet.

Then, on the assumptions that, due to (a) hysteresis, (b) saturation, and (c) variations in air gap, cyclic changes from the true sinusoidal form occur in the alternating magnetic force. This force can be represented by the expansion as follows :—

$$\text{Force} = P_1 + P_1 \sin \{2\pi(2f)t + \alpha_1\}$$
$$+ P_2 \sin \{2\pi ft + \alpha_2\}$$
$$+ P_3 \sin \{2\pi(3f)t + \alpha_3\} + \text{etc.}$$
$$+ \text{cosine terms} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where the first and second terms are the main components, see equation (1), and the third term results from the primary effects of hysteresis and saturation which occur at the oscillator frequency f. The remaining higher frequency terms are due to secondary cyclic variations in the force resulting from hysteresis and the alternating air gap.

Comparing the expressions (2) and (3), it will be evident that, as stated above, resonance of the same mode of vibration as equation (2) may be excited by the progressively higher components of equation (3) as the oscillator frequency is reduced, i.e., when

$$F = f_1 \text{ or } F = 2f_2 \text{ or } F = 3f_3 \text{ etc.},$$

Where

$$f_1, f_2, f_3 \text{ etc.},$$

are different descending values of the oscillator frequency, which are therefore respectively, equal to F, $F/2$, $F/3$, &c. Particular emphasis is given to the oscillator frequency $f_2 = F/2$ which, being the major oscillatory component in the exciting force, gives by far the most pronounced blade resonance.

The possibility of the same resonance in a specimen occurring at a number of different oscillator frequencies may at first sight appear to make a correct experimental determination difficult but, in actual testing, using a two-beam oscillograph with one trace representing the oscillator signal and the other the pick-up from the microphone, no confusion is possible as easily the greatest amplitude occurs in the trace from the microphone when this has twice the frequency of the oscillator trace

As an illustration of the above statement, the diagram, Fig. 9, indicates by means of the thick vertical lines the relative amplitudes of the oscillograph trace obtained from the microphone pick-up during an actual test, when a specimen was excited to resonance at its fundamental, which occurred at $F = 940$ c/s. On the frequency scale employed in Fig. 9 resonance was generally so sharp that it could be adequately represented by the thickened lines shown. During these tests no changes were made in the test conditions apart from adjustments to the oscillator frequency, the values of which are given along the abscissa of the diagram in terms of actual frequency, cycles per second, as well as in fractions of the specimen frequency F.

It will be evident that, as deduced from theoretical considerations, the greatest resonant amplitude of the specimen occurred when the oscillator frequency was one-half of the resonant frequency of the specimen. None of the other resonances produced have amplitudes as great as one-sixth of that value.

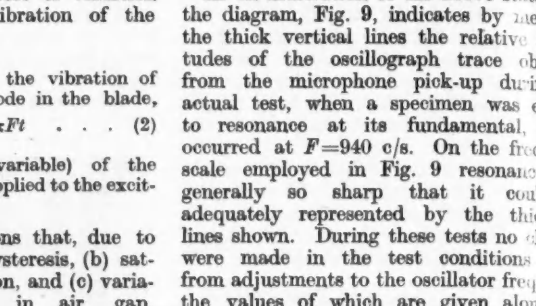


Fig. 9—Excitation of Fundamental Vibration at Various Oscillator Frequencies

The authors express thanks to Sir Arthur P. M. Fleming, C.B.E., D.Eng., Director of Research and Education, and to Mr. B. G. Churcher, M.Sc., M.I.E.E., Manager of Research Department, Metropolitan-Vickers Electrical Company, Ltd., for permission to publish this article.

Diesel Locomotives and Box Car Orders

Five thousand steel box cars, costing approximately 33,000,000 dollars, have been ordered by the Canadian National Railways from Canadian builders. Delivery will start early in 1951 and will alleviate the present shortage in this type of rolling stock. The order brings to 46,700,000 dollars the total spent by the railway on 1950 orders for new equipment. Three companies, the Canadian Car and Foundry, the National Steel Car Corporation and the Eastern Car Company, will share the order. The cars will have a capacity of 50 tons and 3898 cubic feet. They will be all steel in construction with a lining of wood on the sides and ends, and a wooden floor.

The Pacific Great Eastern Railway, in British Columbia, has placed a 1,000,000-dollar order for six diesel locomotives in a move to convert entirely from steam. The new engines are being built by Montreal Locomotive Works and will be delivered early in 1951. The P.G.E. locomotive stock now includes five small diesels, originally designed for switching work.

High Temperature Steels and Alloys for Gas Turbines

IRON AND STEEL INSTITUTE

No. III—(*Continued from page 343, March 16th*)

AT the morning session of the Symposium, on February 22nd, the following papers (Group VII) on "Special Blade Materials" were presented and discussed.

CHROMIUM-BASE ALLOYS FOR GAS TURBINE APPLICATIONS

By E. A. G. LIDDIARD and A. H. SULLY

Methods of production and difficulties due to contamination by oxygen, nitrogen or carbon are reviewed. Melting and casting must be carried out in a vacuum or in an atmosphere free from these elements. Certain chromium-base alloys have creep properties superior to any other alloys investigated at 900–1000 deg. Cent., but have extremely low ductility at room temperature.

SOME COBALT-RICH ALLOYS FOR HIGH-TEMPERATURE SERVICE

By J. C. CHASTON and F. C. CHILD

Tantalum-chromium-cobalt alloys offer promise of service as castings at temperatures round 900 deg. Cent. The alloy containing tantalum 10, chromium 10 and carbon 0·3 per cent was selected for special study, but if maximum creep resistance is required it would probably be advantageous to increase the tantalum and chromium contents to 15 per cent or more.

PHASE DIAGRAMS OF THE TERNARY SYSTEMS Fe-Cr-W AND Fe-Cr-Mo AT LOW TEMPERATURES

By H. J. GOLDSCHMIDT

Phase relationships have been investigated by X-ray analysis for a 600 deg. Cent. equilibrium and the results are discussed. Practical applications of the two alloy systems are pointed out and composition areas indicated which would, on structural grounds, hold promise as heat-resisting materials in gas turbines.

SINTERED ALLOYS FOR HIGH-TEMPERATURE SERVICE IN GAS TURBINES

By R. W. A. BUSWELL, W. R. PITKIN and I. JENKINS

A cobalt-base alloy containing chromium 30, tungsten 6 per cent, has been developed by powder-metallurgy methods. The room-temperature properties compare favourably with those of the cast alloy, but creep properties above 600 deg. Cent. are comparatively low. The possibility of improving the high-temperature strength by the introduction of refractory oxides such as thoria is discussed.

CERAMICS AS GAS TURBINE BLADE MATERIALS

By T. G. CARRUTHERS and A. L. ROBERTS

Available data on the mechanical properties of possible ceramic turbine materials are tabulated. Absence of ductility, sensitivity to thermal shock and inconsistency of properties are the main disadvantages of such materials. Some single-component materials are potentially suitable for use in turbines, provided that operating conditions are such as to minimise thermal shock.

CERAMICS FOR GAS TURBINES

By L. ROTHERHAM, W. WATT, J. P. ROBERTS and F. J. BRADSHAW

The preparation of sintered alumina is described. At 1000 deg. it has bend strength and creep properties superior to those of any metallic alloy in use to-day but it is unlikely to be useful in pure tension. Sudden heating or cooling causes failure. Experimental and theoretical approaches to the thermal shock problem are given.

SWEAT-COOLING

By P. GROOTENHUIS and N. P. W. MOORE

The method of sweat-cooling is discussed and the properties necessary for a sweat-cooled component are defined. These are best provided by powder-metallurgy methods. Tentative designs of turbine blades suitable for sweat-cooling are submitted.

Professor G. Wesley Austin (Cambridge University), in summarising the papers of this Group, emphasised the importance of the development of sweat-cooling, which, however, demanded the design of a new type of material with porosity, controlled in amount and character, as well as adequate mechanical properties. He did not think that the brittleness of chromium alloys at room temperature would thwart their use; the use of an argon atmosphere for melting might cease to be a difficulty if more argon became available owing to the increased use of enriched air and oxygen for industrial purposes. Though the properties of the Ta-Cr-Co alloys were excellent, he did not see where the cobalt and tantalum were to come from. The papers on ceramics contained much valuable information about refractories, apart from their use for gas turbines.

Dr. H. Sutton (Ministry of Supply) said that the brittleness of the chromium-base alloys at normal temperatures did not encourage the idea that they could be used effectively in their present forms. Though cobalt-base alloys were in a special category on account of the shortage of cobalt, there might be applications for their use in small amounts, e.g., small gas starters for turbines. Dealing with sintered alloys, he referred to the good properties obtained in sintered carbides. Experience with ceramic materials had been small, but one particular example, the Bureau of Standards 4811, a beryllia-zirconia-alumina, had shown considerable promise. In sweat-cooling they had to consider two opposing influences—the loss of mechanical properties by porosity against the gain by reduced temperature due to cooling.

Dr. Howard Cross (Battelle Memorial Institute, U.S.A.) referred to work at Battelle on the chromium-base alloys (mainly chromium 60, iron 15–25, molybdenum 25–15 per cent), which had led to conclusions similar to those of Liddiard and Sully. The principal difficulty was lack of room-temperature ductility and shock resistance. To overcome this, he thought that future work should be directed to chromium metal. Chromium made by the thermal decomposition of chromium iodide had recently given encouraging results, in that crystals, though brittle when struck by a hammer, could be reduced 40 per cent in compression before cracking occurred; and some crystals arc-melted in an inert atmosphere could be similarly deformed.

Dr. W. Woodward (U.S. National Advisory Committee for Aeronautics) said that, so far, they had not developed a material that was practicable for a ceramic turbine blade. They had found the Bureau of Standards multiple-component ceramic 4811 better than some single-component ceramics that they had tested. The main drawbacks were low resistance to thermal and to mechanical shock. To improve these properties they were tending to add metals, producing "ceramels" which were mixtures of a ceramic and a metal. They had investigated materials consisting of a titanium carbide base, with molybdenum, nickel and iron as binders, and were relieved to find that nickel was nearly as effective in this respect as cobalt.

Mr. S. T. Harrison (Armstrong Siddeley Motors, Ltd.) commented on his experience with titanium carbide sintered blading in engines at Coventry. Increase in carbide improved creep strength but made the material more brittle. By using an alloy containing 50 per cent nickel, strengths were satisfactory and the material, though still brittle, could be employed when steps had been taken to modify the blade root. Erosion observed round the top edges of Nimonic blades was completely absent in the case of titanium carbide blades. He emphasised the importance of improving methods of fixing these brittle materials in order to be able to take maximum advantage of their increased strength.

Mr. J. D. Nisbet (General Electric Company, U.S.A.) said that in their laboratory they had first made a general study of the Co-Ni-Fe-Cr system and then made a selection of certain solid solutions, to which they had added small quantities of elements which had relatively low solubilities in these solutions. Mr. Nisbet summarised the broad conclusions to be drawn from this work, one of which was that nickel could be substituted for cobalt if chromium were increased properly. Many cobalt-based alloys could be modified and nickel and iron substituted for much, if not all, of the cobalt, provided that the other elements were properly adjusted.

The remainder of the discussion dealt with sweat-cooling. Mr. P. Grootenhuis (City and Guilds College, London) amplified the data in his paper and said that the method could be applied to many processes in widely varying industries. Mr. F. J. Bayley (National Gas Turbine Establishment) described tests which indicated the great potentialities offered by the technique of sweat-cooling. Mr. S. L. Bragg (William Jessop and Sons, Ltd.) raised some theoretical points for the authors to answer, and Mr. S. Peerless and Mr. N. P. W. Moore (both of the City and Guilds College, London) described recent work on the use of gauze compacts to give the desired porosity and extension of their work to cover the case of a fuel being used as a sweat-cooling medium.

The following papers on "Performance Aspects" (Group IV) were then presented and discussed.

SCALING OF GAS TURBINE ALLOYS

By A. PREECE

The problem of high-temperature oxidation in the gas turbine is discussed, with special reference to the products of combustion of the fuel and impurities which may be present in the fuel.

SCALING OF HEAT-RESISTING STEELS

By C. SYKES and H. T. SHIRLEY

The paper examines the effect of combustible sulphur and of potentially dangerous ash constituents on the behaviour of a range of typical gas-turbine steels under varying air/fuel ratios. Attention is given to the effect of contact with vanadium pentoxide and also, in view of the molybdenum content of some of the steels, to the effect of molybdenum oxide.

FATIGUE AT HIGH TEMPERATURES

By H. J. TAPSELL

Consideration is given to the general characteristics of the behaviour of metals in fatigue, together with the modifications introduced by the presence of mean steady stresses, which cause creep. The effect of plastic strain in modifying stress distribution is described, and it is shown that cyclic speed of stressing is an important factor. Experimental fatigue and creep data are given, and the method of correlating them in working stress diagrams is shown. Short statements are included on investigations into the effect of exhaust gases, small fillet radii and welds.

FATIGUE TESTS AT ELEVATED TEMPERATURES

By P. H. FRITH

Results are given of fatigue tests at elevated temperatures on hollow specimens of heat-resisting

materials under reversed bending stresses, or under reversed bending stress superimposed on static tension or a static bending stress. A few tests were carried out on turbine blades.

HOT FATIGUE TESTING

By H. E. Gresham and B. Hall

The design and construction of suitable apparatus is described, and its adaptability for use for corrosion fatigue testing with corrosion media in the form of gases, solids or as a spray, is illustrated.

VARIATIONS OF ELASTIC MODULI WITH TEMPERATURE FOR VARIOUS STEELS AND PURE METALS

By G. T. Harris and M. T. Watkins

Determinations of Young's modulus have been made up to 800 deg. Cent. by static and dynamic methods, the results of which agree within 1 per cent. The variation with temperature of the modulus of rigidity and Poisson's ratio has been determined for steels G18B and R20.

Mr. D. G. Sopwith (National Physical Laboratory), who introduced the papers of this group, said that, apart from the determination of physical constants, they all dealt with the effect of service conditions in the gas turbine, the effect of scaling (and particularly of vanadium pentoxide) and of fatigue at high temperatures. He commented on the wide difference in the vanadium content of fuel ash and said that it appeared from the papers that the most hopeful means of minimising attack by vanadium pentoxide was by addition to the fuel of metallic oxides, which would form vanadates of high melting point and so increase the range of temperature within which no attack occurred. Dealing with the subject of fatigue, he said that in addition to the variables affecting fatigue resistance at ordinary temperatures, there was the added variable of temperature itself, and a further one in that speed effect had also to be taken into account. Time was generally not available for carrying out a complete series of tests, but means were indicated in Mr. Tapsell's paper of making use of a comparatively limited amount of information to obtain a reasonable picture of the behaviour of a material over the whole field.

Mr. E. R. Gadd (Bristol Aeroplane Company, Ltd.) said that in the early stages of turbine engine development more attention had been given to creep properties than to hot fatigue testing. Although blade material usually had lower fatigue resistance in the cast condition, alloys having good creep and fatigue properties in the cast condition had been developed. Nevertheless, the idea of using cast rotor blades had not received much support in this country, largely because of difficulties of inspection. The papers of Tapsell and of Frith included references to the combined effect of creep and fatigue and it seemed possible to determine a temperature above which creep predominated and below which fatigue was more important. Determination of such a temperature was also of importance to engine makers in connection with aluminium alloy pistons as both fatigue and creep were factors in piston failure. He believed it could only be done by combined stress tests, in which both fluctuating and steady stresses were involved.

Mr. G. T. Evans (Elliott Company, Inc., U.S.A.) said that the Gas Turbine Panel of a joint A.S.T.M.-A.S.M.E. Committee had sponsored a symposium on the corrosion of materials at elevated temperatures in June, 1950. He referred to some of the information given at that symposium, a full report of which would be available shortly. He did not agree that corrosion difficulties would not be encountered if the metal operating temperatures could be kept below 650 deg. Cent. Eutectics of lower melting point were likely to be present in oil ash, and there was close identity between the temperature at which a molten constituent appeared and that at which corrosive activity became high. He regarded complex vanadates as the true oxygen carriers and trouble makers, and agreed that some kind of oil or ash treatment was the most promising remedy. In gas turbine tests of several hundred hours' duration, with heavy oil having a large excess of calcium in the ash and with inlet metal temperature of 705 deg. Cent., no corrosion of any components had been observed, although there had been fairly heavy ash accumulations, particularly on the stator blades. It was encouraging to note that actual turbine test experience in U.S.A., with heavy oils high in vanadium, was not as bad as laboratory tests would predict.

Mr. H. J. J. Redwood (Admiralty) said that prevention of attack by constituents of the ash was considered to be one of the major problems in gas turbine development for the Navy. To overcome the problem, apart from doping the fuel or removing the vanadium, there appeared to be two methods of approach: the first was to find a metal or protective coating resistant to attack by itself and the second was to cool the blades to a temperature at which attack would not take place or would be substantially reduced. The presence of salt water in the fuel accelerated attack but could be dealt with by methods other than metallurgical.

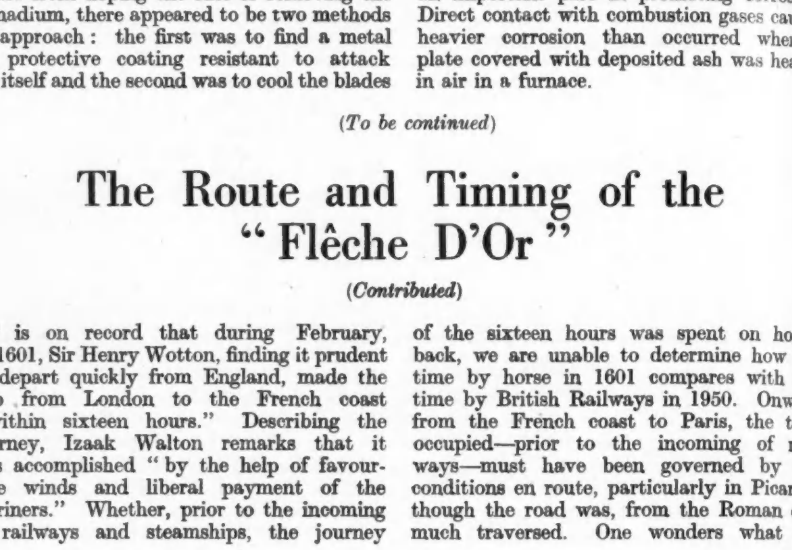
Dr. W. Siegfried (Sulzer Bros., Ltd., Switzerland) said that fouling of turbine blades and excessive oxidation from air heaters due to operating in the temperature range 700 deg.–800 deg. Cent., had been studied intensively by Sulzer Bros. in the 20,000kW power plant at Weinfelden and with special test apparatus in the laboratory. The fouling was essentially dependent on the vanadium content of the oil and the chief cause was vanadium pentoxide, which in a semi-liquid state stuck to the blades. He described laboratory experiments in specially constructed apparatus on materials with different protective coatings. Corrosive attack was considerably reduced by a chalk coating, because adhesion was reduced by the chalk. Not only the V_2O_5 but the alkali (Na_2O+K_2O) content of the oil played an important part in promoting corrosion. Direct contact with combustion gases caused heavier corrosion than occurred when a plate covered with deposited ash was heated in air in a furnace.

(To be continued)

The Route and Timing of the "Flêche D'Or"

(Contributed)

IT is on record that during February, 1601, Sir Henry Wotton, finding it prudent to depart quickly from England, made the trip from London to the French coast "within sixteen hours." Describing the journey, Izaak Walton remarks that it was accomplished "by the help of favourable winds and liberal payment of the mariners." Whether, prior to the incoming of railways and steamships, the journey from London to the French coast was ever performed in a shorter time than sixteen hours we have not been able to discover. Sir Henry Wotton, impelled by a most fervent desire to keep out of the clutches of Queen Elizabeth, sped through Kent as fast as horses could carry him, but since his biographer does not tell us what fraction of the sixteen hours was spent on horseback, we are unable to determine how the time by horse in 1601 compares with the time by British Railways in 1950. Onward from the French coast to Paris, the time occupied—prior to the incoming of railways—must have been governed by the conditions en route, particularly in Picardy, though the road was, from the Roman era, much traversed. One wonders what the travellers—from Julius Cæsar to Sir Henry Wotton and beyond—might have thought had they known that, later on, the journey would be accomplished (on the surface) in 190 minutes.



FLECHE D'OR AT SPEED

The road from Calais to Paris passes, like the railway, through the Departments of Pas de Calais, Somme, Oise and Seine et

Oise. It is a road along which cluster many historic associations and beside which stand many ancient monuments. Not every passenger on the railway, coming in sight of the towers of Abbeville, will remember that he is quite near to Crécy, where, on August 26, 1346, was fought that desperate and protracted battle between the English, commanded by King Edward III and the Black Prince, and the French, commanded by King Philip VI. Not until the following morning was the extent of the English success known, a success largely due to the skill and toughness of the archers. The site of the English crossing of the Somme was at Blanchetaque, near Abbeville.

Passing through this historic region, one realises that among the advantages of rail travel is the opportunity of surveying the scenery and objects along the route. To many travellers this is a refreshing experience and it is surprising what a lot can be seen from the windows of a train. Many are the glimpses of churches and châteaux, which we will enjoy between Calais and Paris, though we do not see much, from the train, of the great flamboyant church at Abbeville or of that cathedral at Amiens which is described as "the perfect exemplar, the complete ideal of the early thirteenth century style." If this gigantic edifice stood nearer the railway or if we saw it from the "Flêche D'Or," as we see Durham Cathedral from the "Flying Scotsman," there would be more visitors to Amiens Cathedral. For the present writer one of the most interesting of the innumerable glimpses on the railway journey to Paris is obtained opposite km post 67·5 (north of Clermont), where an ancient Romanesque church shorn of its east end and now used, apparently, as a barn, stands adjacent to an old farm-house. It is seen on the right-hand side, looking in the direction of Paris. Very soon after this glimpse we can begin to look out for that impressive approach to Paris with the basilica of St. Denis on the left and the basilica of Montmartre on the right.

While the line from Calais (Maritime) to Paris is, for British passengers, the most familiar railway route on the Continent, it is not generally known that this particular stretch presents, for fast and heavy trains, a stiff test on the locomotives employed. Leaving Calais (297km from Paris) the first 8km are on level track but from km post 289 the line rises to Caffiers (278km from Paris) on a gradient of 8 ‰ (1 in 125), unbroken except at Frethun, where the ascent eases (for about half a kilometre) to 2·5 ‰. From Caffiers the line falls—almost entirely at 8 ‰—to km post 267·5. Thence the railway undulates with short rises and falls at 8 ‰ to km post 250, where begins the climb to km post 237·5. From this point there is a descent through Etaples (226km from Paris), whence there is an almost level galloping stretch of 60km through Abbeville to Pont-Remy. Thereafter the track undulates on easy gradients with level stretches to Amiens (130km from Paris). From Amiens the line rises to the summit at Gannes (km post 87), after which there is a descent through Creil (50km) to km post 48. Here begins the ascent of the Survilliers bank at a ruling gradient of 5 ‰ (1 in 200), terminating at km post 28. The remaining distance to Paris is downhill at 1 in 200 to km post 8, whence there is an easy rise past St. Denis into the Gare du Nord.

The "Flêche D'Or" (Golden Arrow) runs non-stop from the Gare du Nord to Calais (Maritime), the time allowed (October-December, 1950) being 3 h and 10 min (190 min) for the distance of 297km, thus calling for an average speed of 93·7km.p.h. (58·2 m.p.h.). Trains travelling in the reverse direction—from Calais to Paris—have rather the worse of the gradients, largely due to the commencement, close to the starting point, of the severe climb to Caffiers and to the greater length of the ascents to Gannes and Survilliers, when approached from the north. In the case of the "Flêche D'Or," these circumstances are assessed, by the time-table (October-December, 1950), as entitling the south-bound train to 4 min longer. With the tare weight of the load behind the tender frequently around 500 tons the task of hauling such trains over the route described is a heavy one, though it certainly remains to this day within the capacity of the well-known and well-tested class "231-E" engines of the Nord Region of the S.N.C.F. These locomotives were first introduced on the P.O.-Midi line during 1909, being transferred to the Chemins de Fer du Nord when electrification on the Midi lines rendered them redundant. Their original designation on the Nord was series "231-A," changed, in 1913, to "231-E." Forty-eight in number, these four-cylinder compounds have from time to time been revised in details, a prominent feature now embodied being the Lentz valve gear with cam-operated oscillating valves. The h.p. (outside) cylinders are 16·53 in by 25·59 in, the l.p. cylinders being 25·19 in by 25·59 in and the diameter of the six-coupled driving wheels 6ft 4¾ in. The boiler pressure is 17 atmospheres (241·8 lb per square inch) and the grate area of the Belpaire fire-box 46·6 square feet. In working order the weight (without tender) is 102 tons (metric), and the official maximum speed is 140 km.p.h. (87 m.p.h.) The illustration on page 374 shows "No. 231 E 40" in action with the "Flêche D'Or."

The log of a recent journey from Paris to Calais, when the tare weight behind the tender was 502 tons (metric), is set forth herewith :—

Distance, Paris-Calais	297km (184·5 miles)
Booked time	190 min
Booked average speed... ...	93·7km.p.h. (58·2m.p.h.)
Actual inclusive time on journey	189 min 40 sec
Average inclusive actual speed	94·7km.p.h. (58·8m.p.h.)
Average speed, deducting time of dead stop at St. Roch	95km.p.h. (59·4m.p.h.)
Tare weight of train (behind tender)	502 tons (metric)
Engine "No. 231 E 28." (See log printed herewith.)	

"Flêche D'Or," Paris (Nord)-Calais (Maritime)
November 24, 1950

	Booked	Actual	Intermediate time	Distance from Paris
	h min sec	h min sec	min sec	km
Dep. Paris	12 30 00	12 30 00	—	—
Dead slow to km post 3				
Pass St. Denis		12 37 45	7 45	6
Pass km post 10		12 40 00	2 15	10
Pass km post 20		12 47 15	7 15	20
Pass km post 40		12 59 00	11 45	40
Pass Creil		1 04 20	5 20	50
Minimum speed up ascent to Gannes, 90 km.p.h.				
Pass km post 100		1 34 40	30 20	100
Speed reduced to 80km.p.h. from km post 123 to passing Amiens				
Pass Amiens		1 53 00	18 20	131
Dead slow immediately beyond Amiens to stop for 2 min 10 sec at St. Roch (132·5km post). Rapid acceleration thereafter, Ailly-sur-Somme (140km post) being passed at 106 km.p.h. and Longpré (158km) at 120 km.p.h.				
Pass Abbeville		2 23 30	30 30	175
Pass km post 200		2 36 30	13 00	200
Pass Etaples		2 51 00	14 30	226
Pass km post 250		3 05 15	14 15	250
Pass Tintellerie (Boulogne)		3 13 40	8 25	255
Dead slow through Caffiers and beyond to km post 279·2. Km post 289 passed at 120 km.p.h.				
Pass Calais (Ville)		3 37 00	23 20	294
Arr. Calais (Maritime)	3 40 00	3 39 40	2 40	297

It will be seen that in spite of severe and protracted slacks due to relaying and an unbooked stop of 2 min 10 sec at St. Roch (Amiens), the actual inclusive journey time was 20 sec inside the booked time.

"Flêche D'Or," Calais (Maritime)-Paris (Nord)
November 14, 1950

	Booked	Actual	Intermediate time	Distance from Paris
	h min sec	h min sec	min sec	km
Dep. Calais (Maritime)	2 38 00	2 37 30	—	297
Pass Calais (Ville)		2 42 30	5 00	294
Pass Caffiers		3 00 30	18 00	278
Pass Tintellerie (Boulogne)		3 14 30	14 00	255
Pass km post 250		3 17 40	3 10	250
Pass Etaples		3 33 00	15 20	226
Relaying slack from km post 227 to 224				
Pass Rang du Fliers		3 43 00	10 00	215
Pass km post 200		3 51 15	8 15	200
Pass Abbeville		4 04 15	13 00	175
Pass Amiens		4 29 15	25 00	131
Dead slow from km post 132·5 to 127				
Pass km post 100		4 54 00	24 45	100
Pass Creil		5 21 30	27 30	50
Pulled up to dead stop for 4 min near St. Denis, followed by crawl into the Gare du Nord				
Arr. Paris	5 52 00	6 06 00	44 30	—

The log of a journey in the other direction (Calais-Paris) with engine "No. 231 E 40," is also given and here the booked time was exceeded by 14 min 30 secs, due to severe and protracted speed reductions and a dead stop for 4 min outside the Gare du Nord.

In comparing these runs with a contem-

porary British example, it can be noted that, in the case of the "Royal Scot," which is made up occasionally to a load (tare weight) of about 500 tons and thus comparable with the "Flêche D'Or," the winter time-table (1950–51) allows 93 minutes

Distance, Calais-Paris	297km (184·5 miles)
Booked time	194 min
Booked average speed... ...	92·3km.p.h. (57·35 m.p.h.)
Actual inclusive time on journey	208 min 30 sec
Average inclusive actual speed	85·5km.p.h.
Average speed, deducting time of dead stop outside Paris	87·1km.p.h.
Tare weight of train (behind tender)	488 tonnes

Engine "No. 231 E 40."
(See log printed herewith.)

for the journey Euston-Rugby, the distance being 82·5 miles. This gives an average speed of only 53 m.p.h. (85·29km.p.h.) Since the "Royal Scot" is assisted from Euston to Camden by a banking engine and as the route thence to Rugby is considerably easier—for any equivalent distance—than the route of the "Flêche D'Or," it will be seen that the task of the 7P "Pacifics" hauling the "Royal Scot" (Euston to Rugby) at a required average speed of only 53 m.p.h. is comparatively easy. It will be noted from the log of the run of the north-bound "Flêche D'Or" given above, that the actual average speed was 58·8 m.p.h., notwithstanding delays between km posts 123 and 135; the dead stop for 2 min 10 sec at St. Roch (km post 132·5), and the severe slack at Caffiers.

If the class "231-E" engines of the Northern Region of the S.N.C.F. can accomplish—with a high degree of punctuality—the present loading and timing of the "Flêche D'Or," one wonders what could be knocked off the journey time by the new class "232-U" locomotives, which have the 4–6–4 wheel arrangement, mechanical stoker, and a calculated cylinder effort of approximately 4000 h.p. A four-cylinder compound, weighing 129 tonnes, without tender, and having an adhesive weight of 69 tonnes on six coupled wheels 6ft 7in dia., this mighty machine has maintained a speed of 73 m.p.h. when hauling a test load of 600 tonnes up the Survilliers bank, where the gradient, as already noted, is 1 in 200.

The Institute of Metals

No. I

THE annual general meeting of the Institute was held at the Park Lane Hotel, London, from March 13 to 15, 1951. Mr. H. S. Tasker, B.A., President, took the chair at the opening meeting on Tuesday, March 13, at 10.30 a.m. The Secretary (Lieut.-Colonel S. C. Guillan) announced that since the last general meeting 189 new members had been elected, bringing the total membership of the Institute to 3611.

Report of Council

The President, in moving the adoption of the report of the Council for the year ended December 31, 1950, said that an appeal which he had made to the metallurgical industries of the country for financial support for the Institute had resulted in the receipt under seven-year covenant of an annual income of £4867. In addition, a number of companies, both in this country and abroad, while being unable to subscribe under seven-year covenant, had renewed their subscriptions, the total received under this head so far being £1911. Donations which might or might not be repeated in future years had totalled £1200. These results were very gratifying, and he expressed the thanks of the Institute to the very generous donors of these sums, which would enable the Institute to carry on for a period without any substantial financial anxieties. He mentioned particularly American firms which had donated £1000—donations which they hoped to be able to repeat in future years.

Mr. A. R. Powell, who seconded the motion, informed members that the Council of the Institute had been devising meetings, such as symposia, designed to appeal to the younger metallurgists, with a view to encouraging them to join the Institute.

The report was adopted without further discussion.

Accounts

Mr. W. A. C. Newman (Honorary Treasurer) moved the adoption of the accounts for the financial year ended June 30, 1950. The expenditure of the Institute had exceeded income by roughly £1497, compared with £854 in the previous year, the deficit having been met by transfer from the Wartime Emergency Fund. He pointed out that during the last few years the deficiency in the Institute's accounts had been approximately £2000 a year, and if a deficit of the present size were to continue the Wartime Emergency Fund would soon be exhausted. The successful appeal to the metallurgical industries for funds had been made just in time to prevent the development of a serious gap in the finances which could not have been easily met from current resources. The estimates for 1950–51 showed that the deficit in the present year, due to increasing costs, the increase in the number of papers published and the increase in the number of members, would approach £4000. Therefore, the target of £5000 which had been set in the President's appeal had not been too great. During the seven years of the covenants, the lines on which the Institute should advance and the stability of its finances should be thoroughly investigated. The acquisition of these funds imposed an added trust and responsibility on the Council, the officers and the staff of the Institute to expend them wisely and economically in the interests of the Institute.

Major C. J. P. Ball seconded the motion, and the accounts were adopted.

Election of Officers for 1951–52

The Secretary announced that the following members had been elected to fill vacancies on the Council for the year 1951–52:—President: Professor A. J. Murphy, Professor of Industrial Metallurgy, Birmingham University; Vice-Presidents: Mr. A. B. Graham and Mr. P. V. Hunter; Ordinary Members of Council: Mr. K. W. Clarke and Mr. Christopher Smith.

It was also announced that Mr. Alfred Baer had been elected to fill the vacancy caused by the resignation, owing to pressure of work, of Mr. H. F. Sherborne.

It was further announced that Dr. C. J. Smithells, M.C., had been elected to be Senior Vice-President for the year 1951–52 and would be the Council's next nomination for the presidency of the Institute.

Award of Medals

The President announced that the Council had made the following awards:—The Institute of Metals (Platinum) Medal for 1951 to Dr. R. W. Diamond, in recognition of his outstanding services to the non-ferrous metal industries in connection with researches on differential flotation, as applied to the complex Sullivan ore, and as manager of the largest combined lead and zinc producer in the world; the W. H. A. Robertson Medal to Mr. Christopher Smith, for his paper on "The Extrusion of Aluminium Alloys," published in the *Journal of the Institute of Metals*, 1950, Vol. 76, pages 429–451; the first award of the Walter Rosenhain Medal to Professor G. V. Raynor, in recognition of his contributions to the knowledge of the metallic state and the constitution and formation of alloys.

The President then introduced the new President of the Institute, Professor A. J. Murphy, M.Sc., F.I.M., and inducted him into the chair. Professor A. J. Murphy, on taking the chair, briefly acknowledged the honour which the Institute had accorded to him.

Dr. C. J. Smithells moved a vote of thanks to the retiring President, which was seconded by the new President and carried by acclamation.

The President then delivered his Presidential Address, an abstract from which was published in our last issue.

On the afternoon of Tuesday, March 13th, the first paper to be discussed was:

INFLUENCE OF OXIDE ON THE PRESSING AND SINTERING OF COPPER COMPACTS

By T. P. Hoar, M.A., Ph.D., and J. M. Butler, B.A.

Synopsis

The pressing and sintering of compacts of electrolytic copper powder have been studied with particular reference to the influence of oxide.

A single batch of powder was prepared, freed of oxide by hydrogen reduction at 255 deg. Cent., and superficially oxidised to various oxygen contents ranging from 0·11 to 11·2 weight per cent by controlled low-temperature treatment in oxygen. Small cylindrical compacts were pressed at 10, 20 and 30 tons per square inch; their densities were determined in the green state and after sintering, and their length changes during controlled heat-treatments in reducing and neutral atmospheres were followed in detail dilatometrically.

The porosity of the green compacts, of the order of 15–40 volume per cent, decreases with increase of compacting pressure, and varies in a complex manner with oxygen content. The specific volume increases with increase of oxygen content, in a manner explained in terms of the specific volumes of solid copper and cuprous oxide and of their packing, deformation, and fragmentation during pressing.

During heat-treatment, the compact length at first increases; the length increase is greater than that due to solid thermal expansion, owing to the inflation produced by gas trapped in pores and (in reducing atmospheres) by gases produced in the reduction of oxide. The inflation increases with increase of initial oxygen content up to about 1–2 weight per cent and thereafter decreases. Shrinkage due to oxide reduction and/or metal sintering becomes marked at about 600 deg. Cent; its onset is somewhat hastened by increase of initial oxygen content. The detailed form of the dilation/temperature curves obtained is explained by the superposition of the several expansions and shrinkages.

Dilation/time curves for isothermal heat-treatments indicate little or no shrinkage at 220 deg. and 435 deg. Cent., but initially rapid shrinkage at 665 deg., 755 deg. and 880 deg. Cent. The shrinkage rate markedly diminishes with time, but compacts still shrink slowly even after four hours at 880 deg. Cent. The form of the curves is discussed in terms of current theories of sintering; it is suggested that the ultimate slow shrinkage is limited by the rate of diffusion of trapped gases in closed pores through the metal lattice.

The weight losses of compacts during heat-treatments in hydrogen show that oxide reduction is complete after a four-hour treatment at 435 deg. Cent. or higher. During heat-treatment at 755 deg. Cent. in argon and nitrogen, oxide vaporises from the outer layers of the compacts.

Compacts having initial oxygen contents up to 0·53 weight per cent can be sintered to a final density of about 8·5 (volume porosity about 5 per cent), by heating for four hours at 880 deg. Cent.

or one hour at 950 deg. Cent. For higher initial oxygen contents the final density decreases, but even cuprous oxide compacts (11·2 per cent of oxygen) shrink by reduction and sintering during one hour at 950 deg. Cent. to give a final density of 7·8.

Compacting pressure has only a minor influence on shrinkage rate; its main influence on reduction and sintering shrinkage is indirect—harder-pressed compacts are less porous and have less distance to shrink. Anomalous expansion of certain compacts pressed at 30 tons per square inch is explained by gas inflation due to oxide sealed in by the high pressure.

Dr. A. J. Shaler (M.I.T., United States, said that the subject dealt with in the paper had been undergoing rapid development in the U.S.A., but the paper gave a new insight into what went on in the early stages of the process, when the sintering took place extremely rapidly. He was entirely in agreement with the authors about the plastic deformation which occurred in the first period, but the matter was rather more complicated than that, and those physicists of the solid state who were interested in finding new phenomena would do well to investigate the first stages of sintering, in which there were some things which were not capable of explanation on the basis of present knowledge.

Mr. R. Chadwick (assistant research manager, Metals Division, I.C.I., Ltd.) said that the powder illustrated in Fig. 23 of the paper was similar in appearance to a typical powder produced industrially, as it was initially produced, but there was the significant difference that normally before such a powder could be used it had to be broken down, because, with the very low packing density and very poor flow characteristics, it was difficult to do anything with it.

With the pressing procedure described, the authors must have had considerable difficulty in making compacts in the very narrow parallel wall die with such a poor flowing powder and a low packing density, which meant very long punches. In industrial practice it would be quite impossible to work with a die of that kind with such a light powder. There was no mention in the paper of lubricants, and while he recognised that there were objections to using them, not to use them gave rise to difficulties. He wondered whether the scrupulous cleaning which the authors described had not in fact resulted in the application of a very minute amount of grease to the die walls while they were being cleaned, which would have resulted in lubrication. He also wondered to what extent pushing out a compact from an unlubricated steel die gave rise to sticking, which led to a tendency to small cracks at the side of the compact, which might have quite an appreciable effect on the sintering procedure.

With regard to the mechanism described, when the oxidised powders were pressed and sintered at about 250 deg. Cent., the oxide fim was reduced to a level of 0·1in, and between 200 deg. and 300 deg. Cent. there was a slight expansion which, the authors suggested, was due to the expansion of gas in the pores prior to sintering while the compact was in a weak condition. This was a new conception, but it seemed to be a reasonable one, especially as the expansion at this stage was quite a small one.

In the next stage, at about 400 deg. Cent., there was quite a considerable measure of recrystallisation. At higher temperatures most interesting changes took place and there was very considerable expansion. In relation to this, he had found that there was a definite threshold value of density below which the powder ceased to be permeable to gas. In carrying out work on iron powder, he had found that it depended a great deal on the kind of grain structure in the powder. Some powders ceased to be permeable at as high a porosity as 28 per cent, whereas others were permeable down to much higher densities with a porosity of about 15 per cent. It was important to observe that permeability to gases ceased quite sharply at a particular pressure, so that if the powder were pressed at a somewhat lower pressure, there were two means of reaction with the gaseous atmosphere. First, the gas diffused through the pores, a process which could take place quite rapidly, because a gas could pass through a compact in a partially sintered condition; but, secondly, when this density had been passed, it was not possible to get this permeation of the gas through the pores and it had to diffuse through the metal itself.

By analogy with various types of iron powder, it would seem that possibly the nearest guess that could be made at the threshold permeability values for an electrolytic powder would be about 18 per cent porosity, which was the threshold value for electrolytic iron powder of similar particle shape and not very different compressibility. This would correspond in the authors' work to a pressing load of about 25 tons per square inch. One of the anomalies which the authors regarded as rather important was the behaviour of 0·2 per cent oxygen alloy in expanding to a much greater extent at the higher temperatures than either lower or higher oxygen compacts. This expansion occurred with 30 tons per square inch pressure; it did not occur with 20 tons per square inch pressure. The probability was that the difference between those two materials was that the compacts pressed at 20 tons per square inch were permeable to gases and those pressed at 30 tons per square inch were not permeable, and therefore the only mechanism in those pressed at 30 tons per square inch was the diffusion of gas through the metal itself, so that the products of the reaction could not escape.

The authors described a theory of film formation in which they suggested that an outer skin of oxide was formed on the grains, and this was impermeable to gases and then all of a sudden it burst and caused a blister, which accounted for the expansion. He found it a little difficult to swallow that theory. Where, in fact, was that film in respect of the dendritic grain? Before such a theory could be accepted, he thought it would be necessary to see some micro-sections showing the actual nature of the film and the various changes.

Dr. W. D. Jones (consultant powder metallurgist) commented that the paper dealt specifically with the oxygen content of powder, which in the past had in most cases been regarded as deleterious. It seemed as if that might not be invariably the case. The oxygen content of the powder might have several influences, and the paper dealt with the effect on the sintering properties. It was shown that the activation of the copper surface, presumably by reduction of oxide, might actually cause shrinkage to begin sooner and perhaps at a lower temperature. This was a matter which must be borne in mind from the practical point of view. It might be that further work on this subject would show that there was an optimum oxygen content in order to produce compacts having the desired porosity.

The oxygen content also had an influence on the green strength of a pressing, and it was generally believed that the more oxygen content, the lower was the green strength. He had some doubts about that generalisation, and it would be interesting if the authors had an opportunity to extend this work somewhat and throw some light on that point and also on the influence of the oxygen content on the final physical properties of a compact.

A very important aspect of the oxygen content of an industrial powder was that it influenced cost of production. It was comparatively easy and cheap to produce a copper powder, by atomising or by mechanical methods, having an oxygen content of 0·1 per cent. By gaseous reduction or other treatments it was industrially possible to produce an oxygen content of one-tenth of that value—0·01 per cent. He imagined that to get the figure any lower would be an expensive matter. Thus, from the point of view of the cost of the powder, which was very important industrially, there must be an optimum oxygen content. It would be very desirable if the authors could carry this fundamental work further and ascertain what was an optimum oxygen content, taking into account all the various practical factors.

Dr. J. C. Chaston observed that the small amount of work reported in the paper on sintering in argon and nitrogen was of very great interest. The effect of sintering in argon was actually to give a bigger density than ever resulted from sintering in hydrogen, and he could not think that this was only due to the effect of blowing up. He felt that this aspect was important and deserved much more attention.

Mr. J. M. Butler, in a brief reply to the discussion, said that the purpose of tumbling or ball-milling powder in industry—to which Mr. Chadwick had referred in his reference to breaking down the powder—was not to give a better shape for an increase in compacted density, but merely to give a better flow so that the mass production methods used in industry could be carried out. In those continuous machines it was necessary to have a powder which would flow into the orifice automatically from a feed. It was true that the compacting process would break down the particles and that the particle size as determined on the powder was almost certainly not to be compared with the sizes of the particles actually in the green compacts.

As to lubrication of the die, the authors certainly had not used any lubricant. The procedure had been to swab the die with acetone, and no grease had been introduced at any stage. Provided that the powder was very carefully removed from the walls after each compaction (a little had stayed on), then no sticking occurred in further compacting.

It was a fact that recrystallisation took place in compacts when heated at 400 deg. Cent. for an hour, but he doubted whether it would occur when the compacts were heated through 400 deg. Cent. at a rate of 30 deg. Cent. per minute.

Mr. Jones had suggested that it might be shown that there was an optimum content to obtain the greatest density under certain sintering conditions. He believed this to be true, particularly as in industry oxygen contents were used of the order of 0·1 per cent or 0·2 per cent, and there were fairly rapid heating rates. It was precisely under those conditions that the greatest expansions might occur if the oxygen content was not an optimum oxygen content.

It might be of interest to Dr. Chaston to know that in America there had been a certain amount of study of the mechanism of sintering in alloys. Work which the authors had done at Cambridge had been followed by some experiments on the sintering of copper-nickel alloys. The shrinkage curves obtained using compacts of copper and nickel mixed had been very similar to

those obtained with pure copper alone. There was considerable evidence that a great deal of diffusion occurred in the early stages of the sintering of these compacts which, instead of giving a more dense compact, might even produce greater porosity than would happen in the case of one constituent alone.

The following paper was then presented :—

STRESS-AGEING TREATMENT AND ITS EFFECTS ON THE PHYSICAL PROPERTIES OF COPPER, IRON and ALUMINIUM-BASE ALLOYS

By R. F. Gill, B.S., E. A. Smith, and R. H. Harrington, Sc.D.

Synopsis

"Stress ageing" is a treatment which consists of heating an alloy, for the correct time and at a suitable temperature, while it is subjected to a specific stress from an external load. By this treatment it is possible, in alloys that possess recrystallisation temperatures effectively above room temperature, to double and almost treble the elastic properties, to increase the tensile strength, and simultaneously to raise the elongation and electrical conductivity. These effects may at present be explained within the framework of the Phase Rule by supposing strain-induced solid-state reactions to take place within elastic solid-solution crystal lattices.

More economical use of alloys, replacement of higher-cost alloys by previously inferior materials, and some saving of certain strategic metals, may prove possible by the employment of stress ageing. The incidental occurrence of this phenomenon during engineering service of alloy parts may prove to be a major factor in fatigue, in second-stage creep, &c. The detailed effects of this treatment on the properties of eight copper-base, five iron-base, and eleven aluminium-base alloys are presented.

Discussion

Dr. J. McKeown (Head of the Mechanical Testing Section, B.N.F.M.R.A.) said that he could not see that the authors had produced any evidence that stress ageing differed from strain ageing, the effect of which on elastic and quasi-elastic properties of metals had been known for many years. The authors suggested that stress-aged materials could be used as springs. He asked whether this suggestion was based only on the improvement in elastic properties in one direction. A spring had to withstand compressive as well as tensile stresses. Had the authors tested the elastic properties in compression and found an improvement? It would seem to him that stress-aged or strain-aged material could not be formed into springs if the forming operation involved plastic deformation and still retain the high requisite limit of proportionality.

Mr. D. McLean (Metallurgy Division, N.P.L.) observed that the authors found essentially that their stress-ageing treatment improved the proof stress and limit of proportionality and the perfection of the crystal structure, and the cause to which they attributed these changes was strain-induced precipitation, which was a calculable effect similar to the effect of pressure in lowering the freezing point of water. The order of magnitude was indicated by the fact that to lower the freezing point of water by 1 deg. Cent. a stress of roughly 1 ton per square inch was necessary. The authors had investigated about two dozen different alloys, some of them multi-phase and some single-phase, and had found that stress ageing operated to some extent in all of them.

In his opinion, however, it was improbable that there would be enough precipitation brought about by a stress of some tons per square inch, especially in the single-phase alloys, to produce the effects observed. But he thought there was an alternative explanation which might apply in all those cases, since, although there might be some doubt about whether it could give an effect of the magnitude observed, it would nevertheless be general. It was that the combined or consecutive action of stress or strain and temperature produced polygonisation, i.e., the original crystals broke down into a mass of sub-crystals.

The stress-ageing treatment must tend to produce such a structure. The sub-boundaries of the polygonised units were considered to be arrangements of dislocations, and the reason for this was that the arrangement of dislocations in rows was more stable than the random arrangement characteristic of the cold-worked condition. Since such an arrangement was more stable, it followed that a force was necessary to pull a dislocation out of the rows, and this caused plastic deformation. Ideally, all the dislocations after polygonisation would be more or less uniformly bound, whereas in cold-worked material some would be strongly bound and some weakly bound. The effect of polygonising was to catch up more tightly the loosely bound dislocations. Hence it might be anticipated that polygonised material would have a higher proof and limit of proportionality than cold-worked or annealed material, which also contained loosely bound dislocations; the polygonised material should also have a higher creep resistance, and, since the electrical resistance of cold-worked material was due to the scattering of electrons between randomly situated dislocations, whereas in polygonised material most of the material consisted of blocks of fairly perfect crystal lattice, it followed that polygonisation should also tend towards the electrical conductivity of the fully annealed material, as the authors had found. In creep the polygonised material was stronger than cold-worked material with a much higher dislocation density. He suggested that the reasons the authors had found this general effect of polygonisation was probably that their stress-ageing treatment tended to produce a polygonised structure.

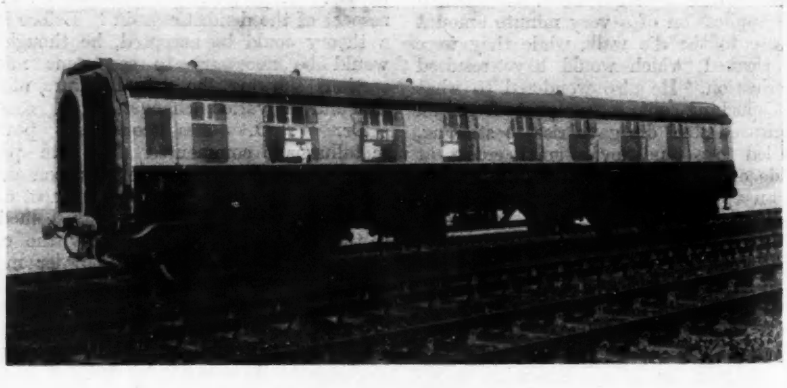
The President (Professor A. J. Murphy) said that according to Dr. McKeown similar effects were producible by the effects of strain ageing. Was it correct to say that in the case of strain-aged material care must be used in applying machining processes? A considerable amount of internal stress was left in the article that was strain aged, and the machining might upset that, with undesirable effects in distortion. Could it not be claimed for stress-aged material that it would be less prone to disturbance as a result of machining of the treated article?

Dr. J. McKeown replied that, while he did not know that the authors' practical claim was ill-founded, he was puzzled as to what was the difference between stress ageing and strain ageing. Stress ageing seemed to him to be a rather dangerous procedure, since it gave rise to creep. From tests which he had made, he did not admit that in stress ageing as done by the authors the creep that occurred would be negligible. There was in the paper no suggestion that stress-ageing treatment could be carried out on the finished article.

(*To be continued*)

Standard Coaches for British Railways

TWELVE types of standard corridor coaches of a completely new design are being built by British Railways, and it is planned to place 1189 of the new vehicles in service by the end of the year. The vehicles, which will include first and third-class corridor coaches, open saloons, restaurant cars, kitchen cars and luggage vans, have been designed to give the widest possible route availability over all regions of British Railways.



Standard Restaurant Car

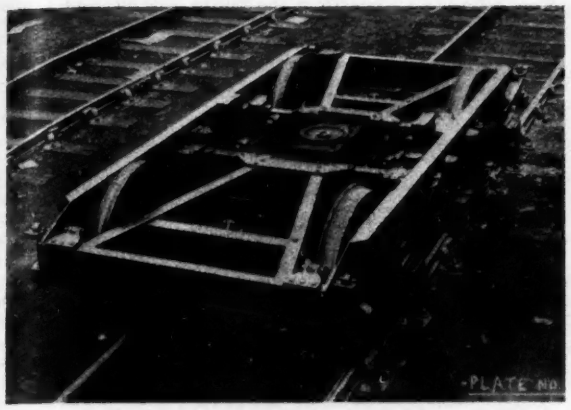
The body structure, underframe and bogies are common to each type of vehicle, and the principal dimensions are as follows :—Length, 64ft 6in; maximum width, 9ft; bogie centres, 46ft 6in; bogie wheelbase, 8ft 6in; and height over roof panels, 12ft 4½in. The new vehicles are of all-steel welded construction and are all being fitted with automatic couplers and Pullman gangways. Drop-head automatic couplers and retractable side buffers are fitted in order that the new coaches can be coupled to existing stock with screw couplings during the transitional period. The automatic vacuum braking equipment fitted to each coach consists of two 22in diameter cylinders fitted with direct admission valves to give accelerated brake applications.

A new design of underframe developed for the standard stock is built to take buffer loads of 200 tons on both the centre coupler and on the retractable side buffers. The underframe is fabricated throughout of standard rolled sections and consists of two centre girders from which cantilevers project to support the sole-bars which carry the body side structure.

For the construction of the four-wheeled, double-bolster bogies, one of which is illustrated on this page, standard rolled sections were also used. These bogies, which are of riveted construction, have a wheelbase of 8ft 6in and wheels 3ft 6in diameter. They are a development of existing double-bolster bogies which

were found on test to have superior riding qualities to single-bolster units.

The vehicle bodies are built up of pressed steel members which are mainly of the "top hat" section. The body framing members are pressed from 10 and 14-gauge deep drawing quality steel, and the body and roof panels, which are of 16-gauge steel sheets, are galvanised. One feature of the body is the shape of the sides, which are in the form of a circular arc from the bottom side to the cant rail. To enable flat glass windows to be fitted to the body the side panels are pressed flat around the window opening. This construction is shown in the illustration below.



DOUBLE BOLSTER BOGIE

The body members have been designed to permit welding assembly in jigs of the main sections prior to complete assembly on the coach underframes. Under the production methods laid down, the body side framing, after having been built up in sub-assembly jigs, is fabricated to form a full-length unit. The body side panelling, which is welded into a complete coach length on a semi-automatic carbon arc welder, is then attached to the framing on a skinning jig by welding, the whole body side being dealt with in one operation. A similar jig assembly method has been adopted for the body ends.

The roof framing members are fabricated by metallic arc welding and assembled to form a complete unit in a jig. Whilst these framing members are still in the assembly jig the roof panels are attached by arc welding. For the general assembly of the body reference jigs are attached to a vehicle underframe and on these jigs the two coach sides are suspended for welding to outrigger plates fixed on the underframe sole bars. This first stage in general assembly can be seen in one of the illustrations on this page, in which the vehicle can be seen prior to the attachment of the ends and roof. The roof is first secured to the sides by location bolts before being riveted in place. In order to facilitate the roof assembly on the body the cant rail is made in two sections, one of which is attached to the roof unit and the other to the side units, and the two sections are riveted together on assembly.

The interior body side and end finishing panels are attached to the pressed steel body framing by hard wood fairings, which are attached to the framing by means of bolts or by studs welded direct on to the pillars and rails. These fastenings are arranged as far as possible to a standard pitch throughout, thus enabling the fairings to be produced in any length and drilled before being cut into lengths to suit requirements.

The flooring consists of $\frac{3}{4}$in thick resin-bonded plywood secured to the pressed steel floor bearers and to the outrigger plates. Blockboard compartment and corridor partitions are appropriately veneered to suit the varied interior decoration. Suitably veneered body side panels and transverse partition finishing panels above the seat backs are of $\frac{1}{16}$in three-ply, while the panelling in the corridor and vestibules is of $\frac{1}{4}$in plywood. The compartment ceiling panels are of plastic material $\frac{1}{16}$in thick backed with $\frac{1}{4}$in ply or hardboard panels, and plastic panelling has also been used for the lavatory compartment walls and ceiling, and for the corridor ceiling. For interior decoration of the coaches some fourteen decorative veneers have been selected; in the corridors and vestibules light-coloured mahogany will be the standard.

The seats in the first-class carriages are furnished with loose sprung cushions, the hinged arm rests between the seats and the head rests having sponge rubber filling. The trimming is of blue patterned moquette; four different patterns have been selected. The seats and seat backs of the third-class compartments are of the unit type, upholstered in moquette, five different patterns having been selected. Hinged arm rests are fitted and so arranged that they fold flush into recesses so that four persons per side can be accommodated if necessary.

The fittings generally follow the same standards in both types of vehicle. Provision is made for tables, two of which are stored in the vestibule. Lighting is by two ceiling lights, which can be dimmed, and four shoulder lights, each with a separate switch.

On brake vehicles the separate guard's compartment is equipped with a desk and cupboard unit, a food warmer, steam heater and a swivel padded seat, from which the guard, by the use of a periscope, can see along the roof in both directions.

Apart from the normal corridor stock, four types of open vehicle will be used. Two of these, one first-class and one third-class, will have separate chair seats for use as dining cars in conjunction with a separa e kitchen car. The remaining two coaches will have fixed seats, and will be used either as dining cars or as ordinary corridor stock.

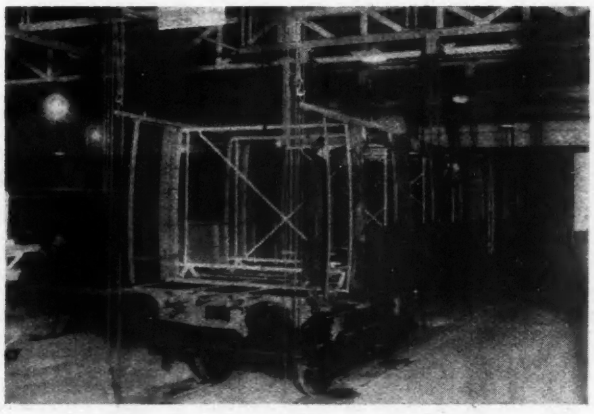
The lighting equipment on vehicles other than kitchen cars consists of a 70A, 24/32V, axle-driven shunt field dynamo with a regulator combining all the necessary switchgear as a unit, and a battery of twelve lead-acid accumulator cells housed in two battery boxes on the underframe. Compartment heating is provided by gilled tube thermostatically controlled steam radiators, which can be regulated by passengers through "Arens" remote-control gear.

Under this first stage of rolling stock standardisation only main line corridor coaches have been dealt with; plans are now in hand for the second stage, covering non-corridor stock for steam and electric services. New designs are also in hand for first and third-class sleeping cars for which the standard underframes and bogies and a similar type of body framing to the new corridor coaches will be used.

Reconstruction of Greek State Railways

THE rehabilitation of Greek State Railways (S.E.K.) has progressed well since a year ago, when rail communications between Salonika and Athens were re-established. During 1950, the efforts of the S.E.K. authorities were aimed mainly at the construction of the new important railway installations at Salonika and the reconstruction of the Salonika–Florina line. The bulk of the reconstruction programme on the S.E.K. network has now been completed, thanks to orders for new materials placed abroad through Marshall Aid funds.

INTERIOR OF BODY SHELL



BODY SIDE ASSEMBLY ON UNDERFRAME

The Salonika–Florina line crosses West Macedonia and extends to Florina and the Yugoslav border. On leaving Salonika it crosses a plain and then a mountainous section, which includes many gradients, the bridges at Axios (2100ft), Gallikos (490ft), and Kouloura (540ft), the four deep viaducts of Edessa and eight tunnels, the longest of which is about 2300ft. The task of rebuilding the badly damaged viaducts was complicated by the fact that they lay on curves of about 1000ft radius over ravines varying from 82ft to 212ft deep. The total expenditure involved in the reconstruction work of the Salonika – Florina line amounted to 24,000 million drachmas, of which about 90 per cent represented Marshall Aid funds.

Fiftieth Anniversary of London's First Electric Tramway

APRIL 4th marks the fiftieth anniversary of London's first electric tramway, which was owned and operated by London United Tramways, Ltd., and ran from Shepherd's Bush to Acton and from Shepherd's Bush and Hammersmith Broadway to Kew Bridge. The nucleus of the system originated in 1873, when authority was obtained by the Southall, Ealing and Shepherd's Bush Tram-Railway Company for a line from Shepherd's Bush to Priory Road, Acton; this line opened in 1876, operated by horse-trams. Six years later, a new company—West Metropolitan Tramways Company, Ltd.—acquired the line and obtained powers to build new lines between Shepherd's Bush and Young's Corner, Hammersmith, on the London/Middlesex boundary, between Hammersmith Broadway and Kew Bridge, and from the Surrey side of Kew Bridge to Richmond. These lines were duly built and put into service, but sisted of just over 8 miles of tramway route, car sheds at Chiswick, Shepherd's Bush and Richmond, 33 cars and 251 horses.

At once the L.U.T. prepared plans to electrify and extend the system, which, by the beginning of 1901, was operating about sixty cars. Their proposals had a mixed and noisy reception; some residents welcomed the prospect of speedier transport, while others looked upon all tramways, whether horse or electric, as unnecessary evils. The dividing line between the rival factions was clear cut and the issue became prominent in local politics. However, the necessary Parliamentary sanction was duly received and the work was put in hand under the supervision of Mr. (later Sir) Clifton Robinson, managing director and engineer of the L.U.T., the plant and wiring being installed by the British Thomson-Houston Company. But the plant and cars, although ready for service, agreeing to pay towards the cost of removing the observatory to Teddington, the electric tramway began operating.

The service started with fifty open-top cars, but the number was increased within a few days to 100; the cars had B.T.H. traction equipment and bodies by Hurst-Nelson. With their lower deck seats covered in tapestry, their curtained windows and their floor mats, these first electric trams were by far London's most luxurious public transport vehicles; the original colour scheme was red with white upper works. The only part of the former horse-tramway not concerned in the change-over to electric traction was the entirely disconnected line from the Surrey side of Kew Bridge to Richmond, which remained horse-drawn until its abandonment in 1912.

OPEN TOP TRAM—1901

ONE MAN CAR—1925

LONDON UNITED TRAMWAYS LIMITED.
Special Saloon Car
To Seat 20.
s. d.
Rate.—7/6 Return for each 1d. of the Ordinary Fare.
Example:
TWICKENHAM TO HAMMERSMITH.
Single Fare by Tram - - - 4d.
Return Fare for the complete party by Special Car - £1 10 0
This Car can be engaged by parties visiting theatres, concerts, balls and other social festivities.
INTERIOR VIEW OF CAR.

SPECIAL SALOON CAR FOR PRIVATE HIRE—1902

On July 6, 1901, an extension was opened from Kew Bridge to Hounslow, and four days later the extension of the Acton line to Southall was inaugurated, the occasion being celebrated as the formal opening of London's first electric tramway, although parts of the system had, of course, been in use for over three months. By then another fifty cars had been added to the original fleet; they were slightly different and had Milnes bodies and Westinghouse equipment. In their all-cream livery they were very smart and it was probably for that reason that ten of these particular cars were used for the inaugural ceremony.

Over the next few years many new extensions were opened, mostly into districts that were essentially rural. In 1902 the line opened from Isleworth to Twickenham and from Twickenham to Richmond Bridge; a year later it was extended from Twickenham to Hampton Court round both sides of Bushy Park, i.e., both via Kingston and via Hampton Church. The fleet had by then been doubled, the latest 150 cars having more powerful Westinghouse motors, and bodies by various makers. These cars were finished in blue with white upper works and, for a few years, cars in the respective colours—red, cream or blue—operated on separate routes, thus continuing for a while the colour scheme of the original horse-tram routes.

In 1904 came the service from Southall to Uxbridge and also the link between Hammersmith Broadway and the Uxbridge Road at the Askew Arms (another point on the London/Middlesex boundary). Two years later another link between the two main branches was put in between Brentford and Hanwell, via Boston Road. Up to 1906, the L.U.T. had restricted its activities to north and west of the Thames, except for the short isolated section alongside Kew Gardens, but in that year it launched out into Surrey and by the following June had established tramways from Kingston to Ham, Richmond Park gates, Kingston Hill, the Dittons and Tolworth, whilst another line ran as far east as Tooting. At that time forty cars of a new design were added to the fleet. They had full-length upper decks and covered tops; they embodied Westinghouse equipment; their

despite a courageous but abortive experiment with a battery-operated horse-car in 1883, the West Metropolitan concern failed financially and in 1894 another new company, London United Tramways, Ltd., with registered offices in Bristol, took over their assets, which con- stood idle for six months owing to the belief of the Kew Observatory authorities that the use of the usual earth-return via the track would interfere with their instruments. Then, on April 4, 1901, a few days after the difficulties had been resolved by the tramway company

bodies were by the United Electric Car Company, and they were finished in red with white upper works similar to the 100 with which the service originally opened.

The year 1907 saw an end to L.U.T. tramway extensions and the route mileage then amounted to 55¼ miles, at which figure it remained until the abandonment of the Kew Gardens horse line in 1912 reduced it to 53½ miles. The electric fleet then consisted of some 300 cars and, of the original open-top vehicles, about a third had been given covered tops. Soon afterwards they were given type classification letters and route numbers.

In 1922, under their powers to acquire tramways in the County of London, the L.C.C. purchased the 5 miles of L.U.T. tramway in Hammersmith up to the London/Middlesex boundary, but the company continued to operate this route under an agreement with the L.C.C., who, in exchange, worked the L.U.T. line from Wimbledon Hill to Tooting. Over the years the various other short sections of electric tramway were abandoned—from Hounslow to Hounslow Barracks in 1922, from Twickenham to Richmond Bridge in 1924, and the short length along Lower Boston Road, Hanwell, in 1930. The Summerstown branch was worked by the L.C.C. from 1931. So took shape the L.U.T. system as ultimately handed over to the London Passenger Transport Board in 1933.

Before then, however, control of the system had passed through many hands. In 1902 the Underground Electric Railways Company of London, Ltd., became the largest shareholder in the L.U.T. At the beginning of 1913, L.U.T. interests, with those of the Metropolitan Electric Tramways, Ltd., and Tramways (M.E.T.) Omnibuses, Ltd., were fused in the London and Suburban Traction Company, Ltd., itself under the control of the British Electric Traction Company, Ltd. Two years later, control of the London and Suburban Traction Company, with its subsidiary companies, passed to the Underground Group, although the B.E.T. Company retained some interest.

Throughout these changes, however, L.U.T. retained its identity and maintained its progressive policy. Not only did it establish London's first electric tramway in 1901, but exactly thirty years later it operated the first London trolleybus route (opened between Twickenham and Teddington station on May 16, 1931). The same year, L.U.T., in common with the allied Metropolitan Electric Tramways, Ltd., introduced the 140 h.p., front-exit U.C.C. type trams (the "Felthams"), most of which have now been sold by London Transport and are starting life afresh in Leeds. The original intention was to have these "Felthams" running on reserved tracks on the Uxbridge route, but the plan never materialised. Other innovations included a single-deck tram, equipped with tables and luxurious seating, which could be hired for private parties early in this century; "pay as you enter" one-man single-deck cars were tried between 1922 and 1928 and abandoned; various refinements such as upholstered seats on the upper decks and draught-free ventilation were introduced in 1925, and in 1933 there was put in service a forward-entrance, seventy-four-seater trolleybus (No. 61) that is still running in service to-day over former L.U.T. territory.

Two ambitious schemes that, however, came to nothing were contained in the company's Parliamentary Bills of 1902 and 1903. The former sought authority to construct underground railways from Shepherd's Bush and Hammersmith to Barnes, Charing Cross, Clapham Junction and Marble Arch. This Bill was strenuously opposed by the Metropolitan District Electric Traction Company, Ltd., which itself was proposing to electrify the District Railway and also construct new tubes; the subsequent withdrawal of the Bill was no doubt connected with the fact that in the same year the "Metropolitan District" (now reconstituted as the Underground Electric Railways Company of London, Ltd.), became the L.U.T.'s largest shareholder. The 1903 Bill was for the construction of an underground connection between the company's tracks in Hammersmith and the District Railway platforms at Hammersmith station, a scheme which, it was considered, with the electrification of the District Railway and facilities for through booking, would "prove of great public convenience." The point was never put to the test, however, for the Bill was successfully opposed.

To-day there is no part of the former L.U.T. system operated by trams. It was converted to trolleybus operation, with fifty-six-seater, six-wheeled vehicles, between 1931 and 1935, except for the L.C.C. operated Wimbledon Hill/Tooting section (which, incidentally, was converted to oil-bus operation in Stage 1 of the present Tram Conversion Programme). Thus, when the L.P.T.B. took over passenger transport in London in 1933, its combined tram fleets of 2630 vehicles, operating over 327 miles of route, contained no representative of the pioneer company that had introduced tramways into London, and had discarded them in favour of trolleybuses within the relatively short period of thirty-five years.

Report on Railway Electrification*

THE British Transport Commission has published a report on railway electrification, prepared by a committee appointed at the commission's request by their Railway and London Transport Executives. The committee consisted of Messrs. C. M. Cock, P. Groom-Johnson, W. S. Graff-Baker, J. L. Harrington, F. A. A. Menzler, and E. W. Rostern, and the late Mr. Francis Lydall (of Messrs. Merz and McLellan) who died before the report was published.

The committee's terms of reference required it to report upon the desirability of adopting a single electrical system in all future electrification schemes. It was also to consider whether the country should be divided into separate areas earmarked for third rail and overhead wire respectively. If such a course commended itself, the committee was to indicate the position with regard to the connecting services. The necessity for continuing to use the fourth rail system (standard on London Transport Executive railways) in the light of technical progress was also to be considered. Such important considerations as whether recent progress in electrical practice generally had affected the conclusions of the Pringle Committee were to be reviewed, together with recent developments in the use of electrical operation of freight services and shunting.

In a foreword to the report, Lord Hurcomb states that the executive bodies have now accepted in principle the committee's report and have commended it to the commission. It confirms the main conclusions contained in the Pringle Committee's report of 1927, but contains a valuable study of subsequent technical developments in this country and elsewhere. In brief, the committee recommends that the d.c. system with an overhead line at 1500V should be adopted as standard in all future electrification schemes, except in an area to be earmarked for the third rail system of the former Southern Railway. The commission endorses the reservations stated in the report with regard to any such third rail area, the exact boundaries of which on the western side must be the subject of further consideration. The only other exception would comprise areas within which the fourth rail system may be employed, that is, additions to lines operated by London Transport and also possibly in self-contained and purely urban systems in the provinces.

The report itself outlines the size of British Railways, with notes upon the character, volume and density of the traffic, and a forecast is made on future operating trends, having regard to the standardising of an electrical traction system. A descriptive survey of the various electrification systems follows, together with a note on recent technical advances in design and possible future developments. A chapter is devoted to the decisions taken in other countries on questions of standardisation.

The financial implications of the different systems on the basis of the cost of electrical operation on certain typical sections of British Railways with different traffic densities and different proportions of passenger and freight traffics are worked out for 750V, 1500V and 3000V direct current and for 20,000V single-phase alternating current at 16⅔ c/s.

One of the more important findings of the committee, which are summarised in Chapter XVII of the report, is the establishment of the minimum value of traffic density, expressed as "millions of trailing tons per mile of single track per annum," below which it would be uneconomical to convert lines to electric traction. This minimum value for British Railways is shown to lie between 3 million and 4 million trailing tons per mile of single track per annum, and a map included in the report illustrates the lines of British Railways which are so affected. This map shows that all the main lines between London and the North have traffic densities higher than the minimum given above.

Discussing the choice between the accepted systems of electrification, the report points out that, subject primarily to operational and to a lesser degree to technical considerations, the system which produces the lowest aggregate of working expenses and capital charges should be selected. It is shown that the higher the operating voltage the lower are the first costs of the fixed installation (that is, track equipment and substations). On the other hand, the higher the voltage the higher is the cost of the electric locomotives and multiple-unit train equipments. The relative importance of these two main items of expenditure are dependent on the traffic density. With a high traffic density the reduction in the cost of the fixed installation is, in general, less than the increase in the expenditure on locomotives or multiple-unit trains in view of the large number required. Conversely, with a low traffic density, the reduction in the cost of the fixed installation outweighs the increase in the cost of locomotives or multiple-unit trains. Thus a high traffic density tends to favour the adoption of a low voltage. The report shows that traffic density may consist of a large number of light trains or a small number of heavy trains, and these factors must be taken into account in deciding whether a higher or a lower voltage system would be the cheaper.

Comparative estimates, prepared for selected lines, show that in both capital expenditure and annual expenses, the 3000V system has some economic advantage over the 1500V d.c. system where the traffic density is light. As it is unlikely, however, that lines of low traffic density will be selected for electrification in this country, the difference in cost between the 3000V and 1500V systems does not become the deciding factor. Traffic density, on those lines which are likely to be electrified, is at a level where the economic advantage of 3000V over 1500V is only marginal. Moreover, there is a substantial mileage of lines already in operation on the d.c. conductor rail system at a lower voltage and the provision and maintenance of equipment to allow for a tractor to work on both the 750V and 3000V systems would be less practicable and more costly than for dual working on the 750V and 1500V systems.

These considerations, and the fact that certain lines have been or are being electrified on the 1500V system, lead the committee not to recommend the adoption of the 3000V d.c. system as a standard for British Railways and to confirm the main conclusions contained in the Pringle Report that the standard voltage should be 1500V or 750V with overhead col-

* "Electrification of Railways," British Transport Commission, London, 1951.

lection for the former and third rail for the latter system.

For operational reasons, the report states, it is desirable and economically necessary to retain the existing conductor rail system of the Southern Region and elsewhere. There are, for certain conditions, advantages in the use of the fourth rail system, especially in relation to signalling in an extensive network of single-track tunnels with a dense train service, such as obtains on London Transport. The committee, therefore, recommends the retention of the fourth rail system on existing London Transport railways and its use on any extensions or additions integrated therewith.

Copies of the report on "Electrification of Railways" can be bought from the Publicity Officer, British Transport Commission, 5. Petty France, Westminster, London, S.W.1, price 7s. 10d., post free.

The Fairey F.D.1 Research Aircraft

DETAILS have been released of the Fairey "Delta" (F.D.1) research aircraft, which has now flown. Prior to its first flight, scale models, which were controlled by radio, had been successfully launched and operated. Although no performance figures have been given, certain external features have been described. The D.F.1 has the delta wing plan configuration, with a span of only 19ft 6½in and an overall length of 26ft 3in. A Rolls-Royce "Derwent" engine is fitted, which originally developed 3500 lb. static thrust.

Flying controls take the form of elevons and rudder, which are customary with this type of tailless aircraft. The F.D.1 machine, however, has also small tail planes attached to the rudder and fixed wing tip slots, which have been fitted as precautionary attachments for its early flight testing. Air brakes and wing tip parachutes are fitted to deal with contingencies which might arise on tests and a drogue parachute is housed at the rear of the fuselage to relieve the brakes on the tricycle undercarriage during the landing run. The triangular shaped wing, when fitted to high-speed aircraft, enables the wing structure to be a light yet stiff one and it delays the onset of compressibility effects. It is also possible to stow within this wing profile fuel and equipment, which is a most important consideration with high-speed aircraft.

Other forms of wing plan design, which have been tested in the wind tunnel research programme, at the Fairey works, have included both swept forward and swept back wings and wings which have compounded these configurations. It might be recalled that Sir Richard Fairey was associated with one of the first swept wing tailless aircraft to have flown successfully. This particular machine, which was made and flown by J. W. Dunne in 1911, was found to be inherently stable when in the air.

Books of Reference

The Motor Ship Reference Book, London: Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 15s. net.—The nineteenth edition of "The Motor Ship Reference Book," which has been rewritten, gives up-to-date information of main and auxiliary engines in current use and of the advance of the motor ship from the "Selandia" of 1912, to the "Willem Ruys," of 1947. A chapter discusses four-stroke supercharged engines and another chapter gives detailed descriptions of the principal designs of two-stroke, single-acting engines, while a third deals with double-acting engines. A section of the book is devoted to ships' auxiliary diesel generating sets produced by a number of manufacturers and several engine-rooms of different designs of motor ship are described. The more important Lloyd's rules for the construction of both main and auxiliary marine diesel engines, together with the appropriate tables, are reproduced. There is also a list of builders of marine diesel engines throughout the world, with an indication of the type of machinery built, a chapter on centrifugal separators, and another in which gas turbines are briefly reviewed. The book, which makes available a large amount of information, should be of interest to the non-technical reader as well as of value to the engineer and shipowner.

Pipe Joints for Hydraulic Power Transmission*

By B. COOKE†

THE use of hydraulic power transmission in industry is becoming more widespread daily and the need for greater attention to the efficiency of the ancillary parts of the system more pressing. After seals and gland packings, pipe joints are probably the greatest offenders against "hydraulic hygiene." The choice of pipe joints is limitless and designers may be uncertain as to whether or not a certain type of joint is suitable for a particular application.

There appears to be a paucity of quantitative data upon which designs may be based. The results obtained by the Pipe Flanges Research Committee (1936, 1939) offer little to help the hydraulics engineer. Only the broad principles of some of the joints used by Amagat and Bridgman (1949) can be applied with success. But whilst free from the troubles attendant upon the high temperatures of steam joints and the high pressures met in high-pressure physics, the sealing of a hydraulic fluid presents a serious and separate problem.

The hydraulic pipe joint must combine simplicity of design with ease of assembly and maintenance. The latter is most important, as highly skilled labour unfortunately is seldom available for pipe work. The joint may have to accommodate some degree of misalignment of the pipes and remain oiltight. Mechanical vibration and rapid fluctuations in pressure are more often than not present in hydraulic systems.

The majority of joint rings on the market rely mainly upon high contact pressure intensities to effect a seal. This places unnecessary strain upon the bolts and flanges. The metal joint rings fall into this category with the added disadvantage of requiring a high standard of finish on the mating surfaces.

Some joint rings are claimed to be influenced by the pressure of the fluid they seal. The "Wills" pressure joint is such a case, but it is doubtful whether this joint ring has any advantage over a ring of, say, copper. After being compressed in a pipe joint, the ring, on release, does not regain its initial shape, the amount of recovery being about 0·007in. The makers stress the importance of the surface finish of the mating surfaces of the flanges. The fluid pressure will react upon this joint ring and a solid ring to the same degree. How these rings perform without the internal pressure of the inert gas would be of interest.

The "Lens" and the wave ring described in the discussion of the Pipe Flanges Research Committee can apparently be classed almost as self-sealing. They both suffer the disadvantage of relying on a very fine surface finish. The "Lens" ring requires very substantial flanges, as the effect of pressure on the flanges must be less than that on the joint. With both joints, but more particularly with the wave ring, the success depends largely upon the machining. This latter ring appears difficult to fit or strip, and should a leak develop the inevitable replacement will prove costly.

This paper describes tests carried out on a selection of pipe joints, to find a satisfactory pipe joint for use in gun mountings. Many joints already in use were tested as well as proprietary types. None were found to be satisfactory, but from the experience gained during these tests a pipe joint was designed which has proved satisfactory.

The tests were designed to submit the joints to the most arduous conditions which they were likely to encounter in service. A vibratory test and a transient pressure test were devised. Only those joints which proved satisfactory during the first test and were considered worth while were subjected to the transient pressure test.

On the matter of oil-tightness the author respectfully diverges from the definition as laid down in the First Report of the Pipe Flanges Research Committee. Even a very small percentage of oil leaking on to a deck or floor can be dangerous, and, at least, cause a mess. For a hydraulic pipe joint to be efficient it is essential that it be absolutely oiltight.

The oil used throughout these tests was a service oil OM65, which is a light mineral oil of 65 centistokes viscosity at 100 deg. Fah. The pipes used were solid-drawn steel of 1·0625in bore and 1·3125in diameter.

The working pressure varied from 1,100 lb to 2500 lb per square inch.

RESULTS OF TESTS

From the results of these tests the following points emerge.

The pipe ends should not form the whole or part of the sealing surfaces with the joint ring. In production and assembly it is a great advantage if the pipes can be cut without regard to accuracy or finish. It is apparent that provision for this in designing the flange is usually possible. Where flanges are required to be removable, a sleeve should be fitted so that the joint can be made upon the sleeve ends. If this design is employed care must be taken to see that all sealing is achieved inside the threads, as they form a leakage path which is difficult to seal. The design of the flanges and sleeves should be such that no further machining is necessary after they have been fitted to the pipe ends.

The flanges or sleeves should not be screwed on to the pipe ends. This practice calls for thicker pipe walls than are required to withstand the fluid pressure. The threads considerably weaken the pipe, which under vibration may fracture round the last thread. The use of tapered or vanishing threads only partially alleviates this trouble and adds to production difficulties. Furthermore, if the pipe ends are screwed, the flanges should be screwed on until they become threadbound, and difficulty may be experienced in lining up the bolt holes of the flanges. This will not apply where sleeves are employed.

If the flanges are welded on to the pipe ends care must be taken to see that the bolt holes will line up on assembly. The welding often proves to be porous, and attempts at caulking the leakage have been unsuccessful. The risk of pipe fracture due to vibration is ever present. Brazing has been found most suitable for fixing the flange or sleeve to the pipe end.

Clearance between the pipe and the flange or sleeve should be such that the molten alloy will flow, owing to capillary attraction, to fill up the whole of the available space; in this way the joint will be stronger than a circumferential fillet. The capillary flow will be greatly facilitated if the brazing alloy is preplaced in an annular groove (Fig. 1). With the groove centrally placed the alloy can flow in either direction.

Sleeves similar to that shown in Fig. 1 fitted to a pipe of 1 $\frac{5}{16}$in diameter, with 1 $\frac{3}{16}$in of the pipe entered into the sleeve, were tested for

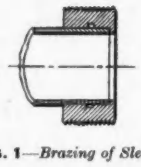


FIG. 1—*Brazing of Sleeves*

strength. Diametric clearances between the pipes and sleeves varied from 2–3 to 12–13 thousandths. All the sleeves were oiltight when tested at 3500 lb per square inch, and they withstood a load of 17 tons in tension (equivalent to a hydraulic pressure of about 43,000 lb per square inch).

In the tensile test, initial failure of the brazing alloy was due to tension caused by the contraction of the pipe; the remainder of the alloy then failed in shear. This contraction would not take place if the end force was due to internal hydraulic pressure. However, it is obvious that the strength of the brazing is more than adequate.

By using sleeves screwed to the outside diameter to take the flanges, manufacture is simplified, as the flanges can be made to serve

* Institution of Mechanical Engineers. March 16th. Abstract.

† Research Department, Vickers-Armstrongs, Ltd., Newcastle-upon-Tyne.

as both spigot and faucet. It is sound practice to have a joint of this type, as the spigot registering in the faucet prevents any radial strain being placed upon the joint ring. The flange screwed to a sleeve obviates the necessity for the pipes to be sprung apart for insertion or withdrawal of the joint ring. The flange acting as the faucet can be screwed back until the joint ring can be inserted in between the sleeves on the pipe ends, and the faucet flange can be returned to the correct position.

In selecting a material for the joint ring it is essential that the fluids to be handled be considered previously. In the tests, and in the service conditions for which the joints were intended, the fluid was a straight mineral oil and presented little difficulty. Any metal or synthetic rubber ring could be used, and there

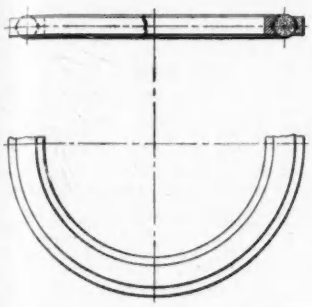


FIG. 2—*Shrouded "O" Ring Joint*

are many materials available which are stable in contact with oil.

Soft metals, such as copper, will make a good permanent joint ring, although they may become work-hardened owing to vibration. Copper must be annealed before use and the mating surface must be well finished, as the metal will not flow to any great extent to fill up any crevices. Material like "white metal" is too soft and extrudes under pressure from the bolts. This may eventually cause leakage by relieving the tension on the bolts. Metal joint rings require a high standard of finish and workmanship in assembly, and should be avoided where possible.

Oil-resisting, compressed fibrous materials are freely available. Like the metal joints, they restrict permissible misalignment of the pipes, and they can rarely be re-used. Joint rings of

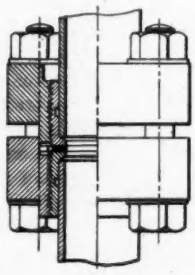


FIG. 3—*Experimental Pipe Joint*

these materials should be fully trapped to ensure that no loose fibres find their way into the system.

Joint rings of synthetic rubber are more satisfactory. The pliability of the rubber enables it to accommodate the unevenness in the mating surfaces, and by careful design up to 2½ deg. misalignment is permissible. The great danger is that too much compression may be applied. Rubber is virtually incompressible and when subjected to pressure it will flow along the line of least resistance. Therefore it is imperative that some provision be made to restrict the compression of the joint ring on tightening up the bolts. This provision can be made either in the flanges or in the design of the ring itself. The well-known "Dowty" ring is an example of a composite ring in which the metal ring restricts the compression.

A complete joint ring designed as a result of these tests (Fig. 2) was a synthetic rubber "O" ring fitted with an inner and outer shroud. This particular ring is for use between flat mating surfaces. The annular space between the two shrouds is such that when the two mating surfaces come down flat upon the metal the volume is equal to that of the rubber ring.

A joint designed on the foregoing lines and fitted with a shrouded "O" ring joint (Fig. 3) was submitted to tests. Each nut was tightened with a torque of 35 lb-ft, and there was no leakage during vibration tests of 5 million cycles correctly aligned, or with the pipes 1½ deg. out of line. During these tests the pressure was maintained at 3500 lb per square inch (1000 lb per square inch) above the proposed working pressure). The same joint was then subjected to transient pressure tests of from 80 lb to 5000 lb per square inch in approximately 0·05 second. Correctly aligned and then misaligned 1½ deg., the joint withstood 200 cycles without leakage.

It was found that the joint remained oil-tight under a static pressure of 5000 lb per square inch with a torque of 10 lb-ft on each nut. This represented a total load of about 2500 lb on each bolt. With 35 lb-ft on each nut the joint contained similar pressure with the pipes misaligned 2½ deg.

Conclusions

The designer of hydraulic systems is working very much in the dark regarding pipe joints. The valuable work carried out by the Pipe Flanges Research Committee and by high-pressure physicists offer very little help. By commonsense application of practical experience a satisfactory joint for a particular application can be designed, but quantitative data is lacking. A committee to investigate hydraulic pipe joints on the lines of the Pipe Flanges Research Committee would produce invaluable results.

Vibration Tests on Cargo Ships

On February 23rd, a communication from the British Shipbuilding Research Association was read by A. J. Johnson, B.Sc. (Eng.), before the North-East Coast Institution of Engineers and Shipbuilders in the form of a paper entitled "Vibration Tests of All-Welded and All-Riveted 10,000-Ton Dry Cargo Ship," We summarise, below, the main points of the paper.

The paper is divided into two main sections, A and B. Section A is concerned with the various practical aspects of the tests, the presentation of the experimental data derived, and their comparison with calculated results. Section B deals with the more theoretical aspects of the work.

Vibration tests were carried out upon two almost identical standard 10,000-ton dry cargo ships, namely, the S.S. "Clan Alpine," of riveted construction, and the all-welded S.S. "Ocean Vulcan." The tests were to obtain data to devise new, and to improve existing, methods of calculating the critical frequencies of ships' hulls, and to obtain information on the vibration deflection forms, effects of loading distribution, change of displacement, depth of water, and amplitudes of vibration in relation to excitation. A specially designed machine excited vibration by means of centrifugal forces arising from a system of rotating masses which had their centres of gravity offset from their axes of rotation. The forces were confined to either vertical or horizontal planes by suitable phasing of the masses. The exciter was mounted on the poop of each vessel and the forced vibrations set up were recorded. Records were obtained of the critical frequencies and vibration profiles in various modes of vibration and in a number of widely differing displacements and loading distributions for each ship. In addition, amplitudes were measured for various magnitudes of exciting forces and records taken of damping curves of free vibrations.

Two-node vertical vibration frequencies calculated by the full integral method or a simple practical form of the energy method are in close agreement with the measured values, but by an approximate method are 10 per cent under-estimated. For three and four-node vertical modes, promising agreement is achieved between calculated and measured frequencies, but for horizontal frequencies there are large discrepancies.

The influence of depth of water is discussed and for the ships tested the two-node vertical frequency decreases noticeably when the depth becomes less than five times the draught. Vibration profiles indicate nodal positions fairly accurately, but are not of sufficient accuracy for detailed analysis. For any particular mode of vibration an approximately linear relationship, between the maximum value of the exciting force and the resonant amplitude of vibration, is indicated. The all-welded ship tends to have larger vibration amplitudes than the riveted ship, suggesting that structural damping is greater in the riveted ship. Despite fairly large changes in frequency the resonant amplitudes per ton of exciting force do not differ appreciably between the loaded and light conditions.

The applications of approximate formulæ and the full integral method of calculating two-node vertical vibration frequencies are discussed. A number of full integral calculations appear to confirm that it is sufficiently accurate to assume an evenly distributed load over each of twenty equal sections in the length of the ship. Towards the calculation of higher mode critical frequencies a simple practical method is developed upon the basis of energy principles.

The influences of shear deflection and rotational energy are discussed, and existing methods of allowing for these effects in frequency calculations are reviewed. Frequency correction factors are estimated for each mode of vibration covered. Differences between estimated and apparent section moduli of the ship girders, as revealed by static bending tests, are discussed in relation to frequency calculations. Methods of calculating horizontal vibration frequencies are investigated and an attempt made to establish empirical relations between two-node vertical and horizontal frequencies. An analysis of the "amplitude-exciting force" measurements yields interesting information upon several aspects of ship vibration, but the data are too scanty to form definite conclusions. Indications are given of the values of ship damping coefficients and the manner in which they vary with frequency and using these coefficients resonance curves have been drawn which give information upon critical speed ranges. The application of Clerk Maxwell's theory of linear and angular displacements can determine approximately the influence of the position of application of exciting forces and from existing knowledge it appears possible to predict the effect of an exciting couple applied at any position in a ship. The relationships between equivalent exciting forces and couples are given. Appendices give specimen calculations of natural two-node and three-node vertical vibration frequencies by different methods.

Cast Steel Frame for Crushing Machine.—A single 12-ton steel casting, 10ft 6in long and 5ft 6in wide, has been supplied by David Brown-Jackson, Ltd., Manchester, to form the main frame, complete with bearing pedestals, of a sledging machine 36in by 24in, having an ore or stone crushing capacity of 80-90 tons per hour. For a casting of this kind special arrangements were needed for the moulding and pouring operations. The casting was poured from a special melt of closely specified carbon steel. The frame finally underwent stress relieving treatment and radiographic inspection.

Sir William J. Larke Medal.—The Institute of Welding has awarded the Sir William J. Larke Medal for 1950 to Mr. I. C. Fitch, electrode development engineer in the welding department of Metropolitan-Vickers Electrical Company, Ltd., for his paper on "Arc Welding Electrodes—their Uses and Abuses." The medal was presented to Mr. Fitch at the Institute in London on February 28th.

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NAVAL POLICY AND REARMAMENT

THE Commons' debate on the Navy Estimates was of particular value in correcting the unfortunate impression created by the Prime Minister when he recently attempted to explain the reasons for the appointment of an American Admiral as Supreme Commander, Atlantic. "The defence of the North Atlantic," said the Prime Minister, "cannot possibly be undertaken in future by this country alone." The nation, of course, realised only too well that it had required the Communist aggression in Korea to awaken the Government to a sense of its responsibilities. But had we really sunk so low that the Royal Navy could no longer hope, without allies, to protect our trade against attack by the naval forces of one Continental, and mainly military Power—the Royal Navy which kept the peace of the world for 100 years and has always been regarded as the country's sure shield in time of danger?

Happily, Mr. Callaghan, Parliamentary Secretary to the Admiralty, who opened the debate, was able to give a much more cheerful appreciation of the naval situation. Dealing with the North Atlantic Treaty Organisation, in a clear and concise survey of our naval problems, he pointed out that the balance of sea power had tilted away from us very dramatically during the last ten years. While, however, our Fleet had been outnumbered by a friendly ally, there had been at the same time a profound change in the strategy of the defence of these islands. The North Atlantic Treaty Organisation was, indeed, a recognition of that change and of the fact that the Navy could no longer, on its own, prevent invasion from the Channel. This sound and accurate summing up of the situation is very far from an admission that the Royal Navy can no longer be expected to safeguard our food and raw material supplies and our troop transports. Rather is it a recognition of the changed conditions—of the fact that the danger is no longer from troops coming in ships from overseas, but from airborne troops, V2 rockets and atom bombs from enemy-occupied ports across the Channel and the North Sea. British policy, be it noted, has not changed. On the contrary, the need is now more urgent than ever before for adhering to the policy consistently maintained over the past 200 years of ensuring that no strong Continental Power should occupy the ports of Northern Europe. It is only our traditional strategy that has changed—the landing of a small contingent of troops on the Continent while maintaining a Navy strong enough to meet any conceivable combination of Powers against us. But there are many who believe that there has been too great a change—that our European commitments are absorbing our resources at the expense of the Navy.

The 1921 Washington Naval Treaty, laying down a 5 : 5 : 3 ratio in capital ships as between the navies of this country, the United States and Japan, implied a recognition of the fact that war against the United States is no longer even thinkable. There was, however, at that time no German Navy and the Treaty still left our Navy on a two Power standard basis in relation to the rest of the world. But because of our neglect since the war to build vessels capable of dealing with the modern submarine—the ideal warship for a nation not requiring to use sea communications—this country is now in an awkward and dangerous situation. Apart from our obligations under the North Atlantic Treaty, Britain must inevitably play an important part in the defence of the Elbe frontier, if these islands are to be safeguarded. This is not, however, to say, as Viscount Alexander has said in the Lords, that it would be wrong to suggest a naval programme in proportion to the demands of the Army and Air Force. The danger from starvation is no less real than the risk of bombardment or invasion from the air. Indeed, this is clearly realised by the Government which is now doing its utmost to make up for lost time in strengthening the Navy. The number of anti-submarine frigates to be laid down is to be limited only by the provision of their machinery; and by the end of next year no less than 30 per cent of the shipbuilding and ship-repairing personnel available in this country will be engaged in naval work, compared with only 2 per cent in 1948. In view of the necessity for preserving our peacetime economy, 30 per cent is a very large proportion and is a measure of the urgency which the Admiralty attaches to the naval building programme now that the Government has moved the telegraphs to "Full ahead." It is intended by the end of 1955 to complete a total of 232 new ships, including six aircraft carriers and eight destroyers building since the war. Twenty-four of these will be frigates of new design and nearly 200 will be minesweepers and other small craft. Already seventeen frigates, forty-one minesweepers and twenty-eight patrol vessels have been ordered. The Parliamentary Secretary also made it clear that the Admiralty has now decided on the proportion of destroyers which it can afford to convert into anti-submarine frigates. By the end of 1955, forty-five of our existing 110 destroyers will have been converted and another twenty-five modernised. Russian vessels of this type are unlikely to be used to any great extent on our trade routes, but Russia appears to have at least eighty destroyers and it is no doubt wise at this stage, when yards will soon be working at maximum capacity, to delay a decision on the remaining forty British vessels. Meanwhile, the policy of converting as many destroyers as our resources permit is unquestionably sound. There are no battleships to attack, but there is urgent need for a large number of fast anti-submarine vessels, with good endurance and good sea-keeping qualities, to act as convoy escorts. And the conversion of destroyers is the quickest and cheapest way of obtaining them. Conversion costs about £500,000, as compared with £1¼ million for a new anti-submarine frigate of standard design. There will, however, also be a certain number of frigates of simpler design which will cost no more than the converted destroyer.

In the absence of battleships, the role of the cruiser has now become of increasing importance, and there will be general regret that work on the construction of our three cruisers of the "Tiger" class is still suspended because of the need for further research in connection with their armament. We have now only twenty-six cruisers as compared with fifty-nine at the beginning of World War II, and though the number of enemy cruisers and disguised raiders encountered might well be fewer, the seas are just as large and there are still the same number of focal areas of trade requiring protection. The absence of any provision in the estimates for convoy escort carriers is equally regrettable. Merchant ships, suitably converted, made effective escort carriers in the last war, and if the vessels required cannot be spared now, they should at least be earmarked and their equipment provided without further delay. On the other hand, we were given an encouraging account of progress in naval aviation. The Navy is to have the "Sea Hawk" jet fighter this year and the carrier-operated "Venom" night fighter by the end of 1952. The "Wyvern" turbo-propeller strike plane and the "Fairey 17" for anti-submarine operations will also be in use from carriers in the near future. Mr.

Callaghan warned the House that he would soon be asking for an increase in Vote A because of the increased complements required by ships to maintain the new radar and other complicated equipment now required and of the commissioning of a further sixty ships from the Reserve Fleet. He announced also the development of a new steam turbine working at higher pressures and temperatures than ever used hitherto by the Navy, and of a light, small diesel engine with a large horsepower for smaller craft. There is, moreover, a new kind of asdic equipment undergoing tests at sea that detects, locates, aims and fires at a submarine, which is certainly encouraging evidence of the development of submarine detection methods since the war. In general, the Parliamentary Secretary's speech had a most heartening effect on the House. He might well, however, have held out some prospect of an improvement in the position of the Royal Corps of Naval Constructors which is now inadequately staffed for carrying out the large rearmament programme ahead. The recent increases in pay—based on corresponding Civil Service grades—has done nothing either to attract men from the universities and other recognised sources or to stop the constant flow of resignations from those now serving. The only sound solution is for the Corps to form a branch of the Royal Navy with conditions of service and prospects similar to those in the engineering branch.

INDUSTRIAL GAS TURBINES

THERE is a couplet in Pope's "Essay on Criticism" which conveys an admonition not to be neglected by engineers: "Be not the first by whom the new are tried, Nor yet the last to lay the old aside." Pope would have agreed that before anything new can be offered for use—or even for criticism—some creative act is necessary, and that between the accomplishment of such creative act and its translation into a practical tool, there must be a great deal of experimenting and cogitation. This has certainly been so with the gas turbine and we do well to remember that it is a century and a half since an imaginative English colliery proprietor described the scheme of the gas turbine much as we know it to-day. Not for a hundred years after his time was a turbine wheel actually operated by gases from a combustion chamber and even then no useful energy was made available. Later, and considerably influenced by elements used in the development of a novel form of steam generator, the firm of Brown, Boveri and Co., Ltd., applied itself to the actual production of an industrial gas turbine in which a significant part of the heat energy in the fuel was converted into mechanical energy at the output shaft of the turbine. This is not to ignore the many inventors and research engineers who, since John Barber late in the eighteenth, and Dumbell and Fernihough in the first half of the nineteenth century, studied this type of prime mover and made suggestions contributing towards its practical development. In this connection, insufficient recognition has been given to the singular prescience shown by Parsons in his patent (No. 6735) of 1884, one of the most momentous in the history of prime movers.

These remarks are suggested by perusal of a paper read before the Diesel Engine Users Association on March 15th, wherein Mr. G. B. R. Feilden, chief gas turbine engineer, of Ruston and Hornsby, Ltd., gives a factual account of the development work, to date, on a gas turbine generating set of 750kW capacity, the prototype of a production model, the manufacture of which is now being undertaken at Lincoln. An abstract from the paper was printed in our last issue. The history of this development is described by Mr. Feilden with notable clarity and frankness, and it is greatly to the credit of British mechanical engineering that we should have this further example of the publication of information valuable to all who are interested in the manufacture and use of gas turbines. Indeed, gas turbine manufacturers throughout the world display a spirit of friendly co-operation which must surely hasten the introduction of this machine for industrial use. Mr. Feilden's paper describes the problems encountered in the development of an oil-fired gas turbine-driven alternator which, on an installed total weight of 21·45 tons, gives an output of 750kW and a fuel consumption (with heat exchanger) at the rate of 0·55 lb per brake horsepower per hour. Operating experiences with this prototype appear to afford much encouragement, since, while difficulties have certainly been encountered, skill, persistence and enthusiasm have gone a long way to overcome them and at all points progress appears to have been made in the direction of operational security. While the turbines now to be built at Lincoln will, in some details, embody appreciable modification, other details have been found trouble-free after methodical and critical scrutiny. Indeed, in its essentials, the production machine will differ very little from the tested prototype, a result reflecting, as we think, the foresight with which the original components were designed.

It will not be to the advantage of the gas turbine if undue haste is shown in attempting to employ it on duties for which other and —in the meantime—more suitable types of prime movers are already available. As we see it, the industrial gas turbine already possesses a marked attraction for situations where extreme transportability is imperative. It can be operated without water and already its thermal efficiency is something of which we are obliged to take notice. But we must not expect the gas turbine, as the "baby" among present prime movers, to do the work of the "adults." Rather should we encourage its development for those special purposes for which it appears peculiarly applicable. If Carnot were here to-day he would be likely to repeat, relatively to the new prime mover, the advice which he gave nearly 130 years ago when he pointed out the high importance, in the assessment of the properties of a heat engine, of safety, strength and wearing qualities. Carnot also emphasised that "smallness of space occupied or of expense in erecting" were significant factors. He concluded by a statement which reveals his notable sagacity: "To know how to appreciate justly in each case the considerations of convenience and economy, to be able to distinguish the essential from the accessory, to balance all fairly, and finally to arrive at the best result by the simplest means, such must be the principal talent of the man called in to direct and co-ordinate the work of his fellows for the attainment of a useful object of any kind." Someone has well said that "Nothing has a greater hold on the human mind than nonsense fortified by technicalities," and it will be to the advantage of the evolution of the industrial gas turbine if those anonymous commentators who sign themselves "Our Technical Correspondent" will bear in mind that the development of new prime movers proceeds only by the unremitting labours of engineers and is something which must be tested step by step with many setbacks and continuous headaches. That is why we feel refreshed and encouraged when an engineer like Mr. Feilden, after giving an account of his difficulties, describes the efforts made to overcome them.

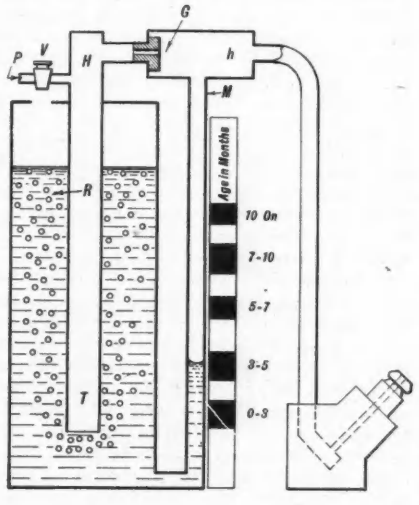
Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

NOT A USUAL SORT OF JOB

SIR,—One of the most difficult initial problems faced by any mother who bottle-feeds her baby, is that of regulating satisfactorily the feed supplied by the rubber teat. How many sleepless nights have resulted from perforce hit-and-miss methods, in the home, of enlarging the hole or holes in the teat with a heated needle: how many puzzled parents have pondered the possibility of being more precise and practical about this pernicious problem?

A research technician of ours was also unfortunate enough to be bothered by this trouble and being of the nature which cannot let ill



alone, he considered spending a little spare time experimenting with his windy first born, and a range of scientifically calibrated teats. He was fortunate in that an accurate air-flowmeter was to hand—in quantity, in fact—and many years' experience on exactly parallel problems of a more industrial nature had got him over the first few fences. Thus, Given the Tools (and a grant of permission from his wife), he set about producing the Right Size of Teat for The Job. On the supposition that no empirical mistakes could be serious, or even more trouble-making than preserving the "status quo ante belchum," the results were tried on the baby.

He had, ere he started, some idea of the field in which the required size would lie; all that had to be done was to measure the flow value (not, of course, the size) of the hole

in an apparently satisfactory teat. This took but a few minutes, but not so did the full experiment. For, alas! time was against him: progress in the infant's growth outstripped the experiments and a few interpolations were needed to round off the figures of the basic theory, leaving it yet to be fully tested. However, results had been so good that a second infant was produced and formed the subject of a full-scale experiment. Success to an unexpected degree was the result and the two children have most satisfactorily passed to the secondary or lollipop stage of feeding. It was found that a very large amount of the feeding problems disappeared and the proud father now feels, with us, that the benefits should be passed on to suffering humanity.

The solution to the problem is to use a range of five different sized teats, according to the physical development of the child. For the factor governing freedom from trouble is the constancy of the time taken to consume the feed; as the baby grows stronger and feeds faster, so the size of the feed increases—but the time for the feed should stay the same. With reservations as to weakly or forward children, it seems the size (in flow) of the teat should increase by 50 per cent every two to three months. The accompanying table shows the ranges of flow based on the British Standard 720 (1948).

Teat Sizes

Size	Normal age (months)	Flow (c.c.)	m/m water level (see diagram)
1	0 – 3	5 – 7	440 – 470
2	3 – 5	7 – 10	390
3	5 – 7	15	311
4	7 – 10	23	217
5	10 onwards	34	132

The method—well tried for other purposes—by which our research technician measured teats is shown on the diagram. Air from a compressor is fed in to the indicating instrument, known as the air controller through a valve *V*. It passes into a tube *T*, whose open lower end is dipped to a fixed length of 50cm in a reservoir *R* open to atmosphere. The air pressure, being higher than the "head" of water, forces some air out to bubble up through the water. This means that the air in the tube is always at an absolutely constant pressure *H*. Any increase or decrease in air pressure fed in at *P* merely causes more, or less, bubbling. The rest of the air escapes through a carefully calibrated orifice *C*, known as the control jet. This jet meters the amount of air at pressure *H* that can escape. From the control jet the air passes over a manometer tube *M* connected to the base of the reservoir—and so down a connection until it meets a further restriction in the shape of the hole in the teat. Now, if the hole in the teat is very large, the air will escape freely, placing no pressure on the water column; if the hole in the teat is sealed, no air will escape and the pressure *h* over the top of the manometer will become the same as the pressure *H* in the dip tube. This pressure will push the water in the manometer tube down to a level equal to that of the bottom of the dip tube *T*. As the hole is progressively opened out, i.e., the size of the teat becomes larger, so the level in the manometer will rise by a proportionate amount. It is then easy, knowing the size of the control jet, in this case 20cc, to place a scale beside the manometer tube; this scale is graduated in cubic centimetres flow, grade of teat and so on. An unpierced teat can be placed on the adaptor and the required size of hole produced in an instant!

SOLEX GAUGES, LTD.

London, N.W.1

STANDARD LOCOMOTIVE No. 70,000.

SIR,—Your article describing the new mixed traffic locomotive No. 70,000, gave much food for thought and further information would doubtless be appreciated by many readers.

Will the pin-jointed cross stays to the horn plates of the driving axlebox guides serve any useful purpose? The frames are rigidly connected by riveted stretchers, and in any case the pin-joints should be in the opposite plane as any relative movement between the two frames would be in a vertical direction if defective track sets up racking strains.

Why have the 2in thick slab extensions of the 1¼in thick main frames been secured by riveting? Surely this clumsy method of connecting the rearward extensions is much inferior to butt welds.

The palm connections of the stays from the firebox back plate to the boiler shell do not look particularly happy and it would seem preferable to have used longitudinal stays carried through to the smokebox tube plate with two or three slings to prevent sagging. Why were the palm stays adopted?

What is the corrugated apparatus shown in dotted lines and extending from the first joint in the boiler shell to a few inches from the firebox tube plate? There is no reference to it in the text and its function is not clear.

Why was a Nicholson syphon omitted from the firebox? Their worth has been more than proved in American locomotives and they must assist in keeping the firebox crown flooded if the water level falls dangerously low. Arch tubes have also been omitted—is it considered that they are undesirable? In passing, can any reader explain why the Drummond water-tube firebox was never adopted by other designers and why it was not perpetuated on the old L. and S.W. Railway? These tubes were said to be very successful and it is recorded that their average mileage was 307,000.

The smokebox is said to be self-cleaning by virtue of a wire mesh grid, which prevents the accumulation of ash—can further details be given, together with an explanation of the action of the wire mesh grid? What length of life is to be expected from a grid of wire in the smokebox atmosphere?

Why has a three-bar crosshead design been adopted? What advantages has this design over the simple single-bar design used so extensively by James Holden of the old G.E. Railway? This rigid, sturdy bar was easily fitted with great accuracy and with its associated crosshead, was comparatively inexpensive.

The incorporation of spring-loaded bronze slippers in the pistons seems to be a departure from established practice, a complicated innovation. Is it really necessary to provide such slippers and how are they accommodated between the piston rings? Can further details be given?

It is surprising that a power operated reversing gear has not been incorporated in a locomotive of this size, and that power operated firedoors have also been omitted. The advantages of power operated firedoors have been stressed time and again by Mr. Livesay and other contributors. Why have they been omitted?

Why is the exhaust steam injector located at almost the extreme end of the locomotive and so remote from the blast pipe connection? The oil separator and the injector itself could have been so easily accommodated between the frames and forward of the first frame stretcher. The long, unlagged, exhaust steam and delivery pipes would have been eliminated and replaced by one cold water pipe from the tender. Remote control of the injector would be a simple matter in these days of reliable "push-pull" systems, of which a number are available. The only objection is some loss of accessibility when the injector and oil separator require servicing—a small price to pay for the advantages conferred by the forward position.

The deflector plates at the smokebox mar the appearance of the locomotive—could they not have been omitted until experience had shown the necessity for them? Provision for the plates could have been made to enable them to be fitted easily if required.

It is hoped, sir, that you can prevail upon the designers to consider the matters discussed in this letter and to reply in a suitable manner in due course.

E. B. PARKER

Cheshire, March 17th.

Literature

Patents for Inventions. By T. A. BLANCO WHITE. Stevens and Sons, Ltd. London: 3, Chancery Lane, W.C.2. Price 45s.

The Patents Act, 1949. By CHARTERED INSTITUTE OF PATENT AGENTS. Sweet and Maxwell, Ltd. London: 3, Chancery Lane, W.C.2. Price 37s. 6d.

The New Patents Act. By ROBERT LOCHNER. National Union of Manufacturers. London: 6, Holborn Viaduct, E.C.1. Price 2s. 6d.

IT is too early yet to make any assessment of how the Patents Act, 1949, is operating. Although the Act came into force on January 1, 1950, and introduced many changes, it will be some two or three years before one can make any comprehensive review to see whether those changes are operating as their progenitors intended. The reason is that, while the Patent Office and practitioners are complying with the new Act and Rules, the decisions are rendered only after each case has "dragged its slow length along"; and usually the more important a case is, the slower does it move. While, however, the new shoots of case law will be slow in appearing, the Act itself has stimulated the quicker growth of commentaries, whose purpose is to analyse, to inform and at times to prophesy. For some time before the war patent practitioners had felt the need of an up-to-date textbook. The last edition of "Terrell" was published only two years after the Act of 1932, and by the time war came it was not only out of print, but needed revision to include the extensive case law arising out of that Act. But for the war it would no doubt have been republished.

Three authoritative commentaries published during the year go far to supply the practitioner's present wants. Inevitably they overlap, but their respective aims and treatments of the subject make them co-supplements.

"Patents for Inventions," by T. A. Blanco White, appeared soon after the 1949 Act came into force. The speed of production is a measure of the author's industry, which is apparent at even a casual glance between the covers. In the main, the book is intended for practitioners; and while certain parts of it are intended for those on the fringe of patent law, those readers will need a full measure of curiosity and courage to thread their way through the comprehensive and thorough treatment which is given to most of the aspects of law and practice.

After the first chapter, which constitutes a justification of the patent system and includes a brief section on its historical development, there are eleven chapters dealing with the constituent matters, such as infringement, validity, the specification and its amendment, assignments and licences. Each chapter is divided into sections, and there are

sub-headings which not only clarify the presentation, but help the reader considerably when trying to trace a particular item. In his presentation the author supports his statements, wherever possible, by reference to decided cases, and there are cross-references between chapters and sections so that one cannot overlook the various aspects of each particular item. Where the author expresses his own views one finds stimulus, even though full agreement cannot be always acknowledged.

The innovations of the new Act are pointed out clearly, and a particularly valuable feature of the book consists of annotated tables of the old and new Acts, giving, section by section, not only cross-references to the new and old Acts respectively, but also reference to the pages in the text.

Another valuable feature of the book, in addition to a discussion of the Registered Designs Act, 1949, is the inclusion in the appendix of the texts of the pertinent sections of related Acts, such as the Income Tax Act, 1945, the Monopolies Act, 1948, and the Copyright Act, 1911. It is undoubtedly a handy and valuable volume. There is an adequate index.

"The Patents Act, 1949," by the Chartered Institute of Patent Agents, is a different type of work, essentially a commentary on the 1949 Act and in no sense a legal textbook.

An introduction summarises the main innovations and is intended mainly for the non-professional reader. Then the text of the Act is given section by section, each followed by a commentary, which gives emphasis to the changes and warnings of the pitfalls. A useful feature is the provision of space for notes after each commentary: legal practice is always in a state of evolution, and a textbook is in one sense soon out of date. The references to decided cases are rather sparing, so that one has the feeling of being in a rather austere and purely textual atmosphere. Yet, in working under the new Act one could take very few false steps if relying on this commentary. There is no doubt that considerable effort has been made in the compilation of this book; this is evident from the Preface, where it is stated that it is the concerted work of certain Fellows of the Institute; but more so from the fact that work of several hands has been well welded into a homogenous whole.

The Act is printed line for line as in the King's Printer's copy—a useful feature for practitioners—and is supplemented by the full texts of the Rules and also by the various forms.

The index is particularly comprehensive and gives references, not only to pages in the text, but also to sections of the Act.

"The New Patents Act," by Robert Lochner, is a booklet of a different character, intending to give to technologists a summary of the Act in non-legal language. This it does successfully, except perhaps in the difficult section dealing with amendments. The booklet is an admirable achievement of condensation: each section is clearly and concisely presented and, furthermore, is adequately supplied with footnotes referring to sections of the Act and occasionally to decided cases. Thus, while one obtains the impression of dealing with a concentrated essence—which the booklet is—there are sufficient instructions for anyone who wishes to water it down and expand it. Additional clarity is gained by itemising certain lengthy sections of the Act, those dealing with publication and opposition being particularly useful. A small chapter treated in this way, listing the various rights of appeal, is of considerable value to practitioners. In fact, although addressed primarily to technologists, the booklet will be found extremely useful by those in practice.

These books are not of the calibre of those of Terrell and Frost in past generations. But they could not be. A completely authoritative book will be written only when the new Act has been in force for two or three years. Yet even if and when that book appears there may be a gap to be filled. A book is now needed dealing especially with practice before the Comptroller. There has been no such book since Romer's, which is now out of date. The new duties placed on the Comptroller—particularly the burden of deciding inventive subject-matter in opposition proceedings—increase the need of such a book.

Manual of Water Supply Practice. Published for the Institution of Water Engineers by W. Heffer and Sons, Ltd., Cambridge. Price 50s.

THIS work, as the preface states, is not a textbook. It is rather to be regarded as an authoritative survey of sound waterworks practice. There are twenty-five chapters, including one on the historical development of water supply and others dealing with water supply law, finance and organisation and management. At the end of each chapter there is a bibliography, which should prove of great value in providing references for further investigation in the special branch of the subject dealt with in the chapter concerned.

The compilation and publication of the volume has been undertaken by the Institution of Water Engineers. Twenty-five working parties, each with its own convener and scribe, have been engaged in preparing the work. Over a hundred experts have contributed the result of their practical experience in one way or another. The work thus has a particular importance and authority for the student.

The first chapter very fittingly and clearly summarises in outline the whole scope of the book and concludes with an historical record of chief events from 1760 onwards, which is unique and interesting. Not less interesting is the chapter which deals with the fundamental considerations in waterworks planning. The writer is inclined to disagree with the statement in this chapter that heavy industries in future will look for their own supplies. For this suggestion is not borne out by the big demands made upon municipalities in most large towns for water for trade purposes and the huge revenue such towns derive from the sale of water for such purposes.

The chapter on hydraulics includes particulars of much recent theoretical work. Experienced engineers of the past designed their works without recourse to the highly mathematical formulæ so lavishly given here. But no doubt the coming generation prefers the more precise methods that greater theoretical understanding may permit. All the chapters of the book are simply and clearly written, and it is this simplicity and clarity which will appeal to the reader.

While the work is the compilation of many minds, the original conception is due to Mr. Aubrey Thomas Hobbs, M.I.C.E., for many years Secretary of the Institution. Mr. Hobbs died when his work was in the hands of the printers and to his memory the Council of the Institution have fittingly and gracefully dedicated his posthumous volume. In this work he had as assistant editor his daughter, Jean L. Hobbs, to whom has fallen the task of seeing the work published. Altogether it is an indispensable volume to all interested in waterworks practice.

SHORT NOTICES

Stress and Strength of Manufactured Parts. By C. Lipson, Ph.D., G. C. Noll and L. S. Clock. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 38s. 6d.—The authors state that they have written this book to assist designers, engineers and metallurgists who, in the course of their work, are called upon to deal with problems of stress, strength and the prevention of failures of parts and assemblies. The information given is directed to showing designers how to formulate a light, economic design, strong enough to withstand severe loads, and enable the metallurgist to specify materials sufficiently durable for service loads and yet not requiring special alloys and heat treatments. The concept of the book is that proper design involves not only stress or strength considerations but the proper balance between the two.

The Extraction of Non-Ferrous Metals. By E. R. Roberts. London: Temple Press, Ltd., Bowling Green Lane, E.C.1. 1950. Price 16s.—Chemical curricula for Intermediate Science Courses have tended to emphasise study of the non-metallic elements rather than of principles underlying the extraction of metals, which form an essential basis for the study of metallurgy. It was in the belief that a thorough knowledge of the general principles involved in metallic extraction was required by chemists and metallurgists alike that this book was prepared. The first chapter—General Theoretical Considerations—deals with the stability of compounds of the metals, especially oxides and sulphides, in the light of their free energy of formation, illustrated by the diagrams of Ellingham and Dannatt, and by the work of Pourbaix. Chapter II—General Practical Considerations—contains an account of the principles of ore dressing and of concentration processes, followed by a classification and description of various extraction methods. These two chapters occupy nearly half of the book. The rest consists of a more detailed account of the chemisty of the extraction of the principal non-ferrous metals, grouped according to the similarity of the principles underlying their production.

The book, based on lectures by Dr. Roberts at the Royal College of Science, is a valuable supplement to the usual chemical textbooks and forms an excellent introduction to a metallurgical course.

BOOKS RECEIVED

Works Management and Organisation. By P. S. Houghton. London: E. and F. N. Spon, Ltd., 15, Bedford Street, W.C.2. Price 25s.

An Introduction to Experimental Stress Analysis. By G. H. Lee. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 44s.

Properties of Lubricating Oils and Engine Deposits. By C. A. Bouman. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 15s.

Mechanical Vibrations. By W. Tyrrell Thomson. London: George Allen and Unwin, Ltd., Ruskin House, 40, Museum Street, W.C.1. Price 15s.

Elements of Heat Transfer and Insulation. Second edition. By M. Jakob and G. A. Hawkins. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 32s.

Consumers' Representation in the Public Sector of Industry. By A. M. de Neuman. Cambridge: Students' Bookshops, Ltd., 4, Trumpington Street, Price 3s.

Some Recent Developments in Rheology. Edited by V. G. W. Harrison (Hon. Editor). London: United Trade Press, Ltd., 24, Bride Lane, Fleet Street, E.C.4. Price 20s.

Oil-Field Exploration and Development. Vols. I and II. By A. Beeby Thompson. Surrey: The Technical Press, Ltd., Gloucester Road, Kingston Hill. £4 4s. per set.

Kent's Mechanical Engineers' Handbooks. Vols. I and II. Edited by Colin Carmichael and J. K. Salisbury. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 68s. each.

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The Institution of Naval Architects

No. II—(*Continued from page 357, March 16th*)

THE first paper presented at the spring meeting of the Institution of Naval Architects on Wednesday morning, March 14th, was :

SOME OBSERVATIONS CONCERNING RESISTANCE AND PROPULSION

By Sir Amos L. Ayre, K.B.E., D.Sc.

Summary

The effect of laminar flow on the model experimental result calls for reconsideration of the subject of resistance, and, since the emergence of the problem has made doubtful much work of the past, a rapid restoration of the situation is necessary. Although predicted results have been fairly closely attained on trial, exceptions were probably caused by the laminar flow condition of the model producing low e.h.p. Results from the various tanks do not assist in supplying answers to the problems which arise and it would help if a standard form of presentation were adopted.

Another important improvement would be the standardisation of the length dimension. This would help to obtain a fixed point from which to measure the L.C.B. position and avoid differences in the block coefficient.

Experience has shown the value of the Alexander formula in determining the speed beyond which both model and ship become over-driven. The relationship between block and mid-ship-area coefficients calls for examination, and there is need for a conventional method for measuring the angle of entrance.

The raked stem influences the above-water form and promotes a vertical distribution of buoyancy, but there is much in favour of the perpendicular design below water. Diagrams illustrate the wide variation of effective horsepower (e.h.p.) obtained by model experiments over the speed range $V/\sqrt{L}=0{\cdot}75$ to $0{\cdot}90$, and it is unlikely that a major portion of it arises from laminar flow.

On the propulsion side the location of the propeller in the aperture does not receive enough attention, and a table gives the gain and loss in propulsive efficiency related to varying clearances of trailing and leading edges. The clearance of propeller tips should not be larger than necessary so as to avoid influencing the amount of water line extension provided in a cruiser stern. It is suggested that the relationship of the propeller diameter relative to the breadth and form of the hull is of importance and to avoid loss in efficiency the diameter should not be less than the breadth $\div x$, and a table gives the values of x for a range of block coefficients.

There is no accepted measure of the advantages from using aerofoil propeller blade sections, and the gain appears to vary with the diameter. The values of ship e.h.p. can be deduced by Mr. A. Emerson's formula. Further points are the desirability of using d.h.p. for the shaft horsepower delivered to the propeller and the dropping of the term "quasi-propulsive coefficient" and using propulsive coefficient for e.h.p. $\div$ d.h.p.

Discussion

Mr. R. W. L. Gawn said the paper implied a tribute to those responsible for the speed of merchant ships, since the author stated that a large measure of success had been obtained by predictions from model experiments to a close degree of accuracy. Theory told us that if laminar flow could be created over the whole of the hull surface the resistance would be remarkably small and consistent. On the other hand, if the flow were wholly turbulent, the resistance would still be consistent, but greater. The difficulty was that with some models of full form, the flow seemed to be largely turbulent, but with sufficient laminar zones to create difficulty, therefore, the condition was one, not of laminar or turbulent flow, but of transitional flow. Realising that full laminar flow on the ship was no more than a dream, the experimenter had endeavoured to ensure consistency by the artificial creation of turbulence. The experimenter could not assess the degree of accuracy of predictions from models tested in stimulated turbulent flow until results of ship trials were available, and the task was now to achieve accuracy in prediction while retaining consistency in the experiment results.

Mr. Gawn said that the use of a trip wire was not an unreasonable device, since it was intended to interrupt the boundary layer and thus eliminate laminar flow. If the diameter of the wire were too large, however, it would extend beyond the boundary layer and constitute an arbitrary excrescence on the hull. The resistance of the wire could vary, but additional complications might arise when the wire was in close contact with the hull of the model. On the ship itself the geometrical equivalent to the trip wire was a rod approaching 1in diameter, and doubtless designers would be disappointed if such rods were fitted to a ship on measured mile trials. It was conceivable that the trip wire over-stimulated by increasing the rubbing velocity and might promote additional eddy resistance: but it was evident from recent researches that some laminar flow occurred on full models.

There was need for caution in interpreting the results of resistance tests on models without trip wires, and caution could not be disregarded in interpreting results when trip wires were fitted. At one extreme, trip wires frequently induced a large increase in hull resistance, while at the other a detached strut ahead of the bow, in the anticipation that turbulence would be stimulated, led to a reduction of resistance of some models. It seemed inherent in the author's remarks on ship predictions that some intermediate device was called for.

Mr. Gawn suggested that until the complicated physics of the problem had been further elucidated, tests should continue both with and without turbulence stimulation. Information would then be available for correlating ship trial results with both sets of model data and for evaluating appropriate correction factors.

Regard should be paid to the propeller as well as to the hull. If the hull resistance was increased by turbulence stimulation greater d.h.p. would be predicted, on account of the additional thrust, and the increased slip and consequent reduction in propeller efficiency. The predicted d.h.p. was subject to correction on account of the small size of propeller model and of any difference in wake between ship and model. Admiralty practice was to ignore the prediction from the d.h.p. as measured on the model and to rely on predictions from methodical series propeller results for the propulsive coefficient, qualified by the factors of hull efficiency, relative rotative efficiency and appendage resistance. By that means a propulsive coefficient was evaluated which was more favourable than that of the ship, having regard to bearing friction, air resistance, surface condition of hull and propeller, sea conditions and cavitation. In many cases the difference was not large, and on the average the ship propulsive coefficient was about 90 per cent of that obtained in the manner indicated. That method of prediction had the advantage that any scale correction involved was consistent, whereas the scale correction in predictions from the propelled model tests depended to some extent on the size of propeller fitted to the ship model. It might help predictions with single-screw merchant ships if that method were considered in conjunction with the usual method.

Referring to uniformity in the presentation of results from model experiments, Mr. Gawn said some advance had been made, thanks to the International Ship Tank Superintendents' Conferences, and the lead given by the British Shipbuilding Research Association in compiling a nomenclature. As to the confusion between length on the water line and length between perpendiculars he said that the Admiralty had adopted the wetted length with satisfactory results.

Dr. J. F. Allan, discussing the change of the allowance factor from 8 to 10 per cent, said that the adjustment of the allowance on the e.h.p. was made because of the changed method of obtaining the propulsive coefficient; the adjustment made no difference to the predicted power.

The other change was an increase of resistance caused by the use of a trip wire. Anything which increased resistance on the model would cause a corresponding increase in the power predicted and the addition of a wire in the model tests made no difference to the performance of the ship. The main source of evidence to re-establish a reliable link between the model and ship predictions was to secure extensive trial trips and to compare the results with those of model tests conducted under the exact conditions that had applied to the ship. He suggested that two years would elapse before we could see exactly where we were getting.

In obtaining the best design for a particular proposition, the use of a trip wire or other turbulence stimulating device on the model was vital.

Dr. Allan said that the figure given by the author of 16 per cent by which the predicted e.h.p. of a ship was increased as the result of a trip wire on the model was exceptional; the average figure from turbulence stimulation was more of the order of 4 to 8 per cent. When the figure was 16 per cent it should be fairly easy to identify the effect; when it was between 4 to 6 per cent it was not so easy.

Dr. Allan referred to tests made at the N.P.L. in which small pins projecting inside the bow profile of the model were used to stimulate turbulence, and the results were closely comparable with those of the trip wire. The pins were placed here and there, and the fact that the results were rather similar to those obtained with wires seemed to dispose of the suggestion that the diameter of the trip wire had a significant effect on the general question of flow.

Dr. Allan urged that the term "quasi-propulsive coefficient" should still be used, for it meant something precise, an actual effective physical efficiency, whereas "propulsive coefficient" did not.

Dr. S. Livingston Smith said the paper gave a warning that changes in experiment tank technique must be accompanied by corresponding changes in the linkage between model and full scale. To produce artificially the requisite turbulence on the model he said that struts were not so reliable as the trip wire. He agreed that in models of full form the effect of the trip wire was to increase the predicted e.h.p. of the ship by as much as 16 per cent. It had been proved that the effect of the trip wire was solely to stimulate turbulence in place of laminar flow on the model, and that was confirmed by aerodynamics experience. Tests sponsored by the B.S.R.A. had shown that (1) the recorded difference in resistance of the model with and without trip wire was exactly equal to the calculated difference using the appropriate skin friction coefficients for the area of laminar flow. That area, which occurred

when no trip wire was used, was measured by turbulence detecting paint; (2) within the limits of experimental error, self-propulsion tests gave the same propulsive coefficient with and without trip wire, and that meant that at the model end we had the true resistance for turbulent flow.

Difficulties arose when we extrapolated to the ship, and it was there that the factor of ignorance lay. The trip wire had removed one of the unknowns and permitted true comparisons to be made between models of different form, and had also removed from model work the instability of flow which could give different results at different times. Linkage between model and ship next needed attention, and just as the old linkage (without trip wire) was built up on years of experience, a new linkage was now required which would be one step forward towards making the science of resistance exact. The way to reach that condition was to have many loaded trials and corresponding model tests, and the B.S.R.A. was represented on as many trials as possible when arrangements were made for the measurement of torque and thrust. When the data were obtained in good trial conditions, the tank tests were repeated in co-operation with the Ship Division at the N.P.L., and the solution of the problems would follow when a sufficiency of model and ship comparisons had been obtained. He felt that the results of the "Lucy Ashton" experiments would give most valuable data.

Commenting on the diagrams, Dr. Smith said that the author's C_2 method of obtaining effective horsepower served as a yardstick to show up any models which were conspicuously good or which were obviously in error. The merit of the late Dr. Baker's model No. 56 (C) was clear from one of the diagrams, and it should be made the subject of further investigation.

Mr. W. T. Butterwick said the paper was helpful to practitioners in pointing out what was really happening, and he welcomed the attention paid to the small differences which were the most serious contributing causes to wide differences in results. Over a long period shipbuilders had been able to rely reasonably on tank prediction, but at the present time they were in a state of chaos.

Mr. J. Lenaghan said that shipbuilders for the last few years had had cause to doubt some of the results obtained, and he hoped that from loaded trials we should get something more realistic, which would give results on which we could rely.

Stating that cargo ships could not get loaded trials and that they were spending more than half their time in ballast, he suggested that tank tests should cover the ballast condition.

He considered that the allowance for appendages must be in question, and had noticed a tendency to go back to the "U" forward section. Owners to-day, he said, were taking a considerable interest in tank tests; they knew that a lot of changes had been made and they wanted to see results. Referring to a recent loaded trial of a twin-screw ship, he said there were doubts about the power, but not about the speed; however, the changed tank technique had shown that the speed would not be obtained. Therefore, two cylinders were added to the engines, effecting an increase of 800 b.h.p., and on trial the ship achieved 13¾ knots against a designed speed of 12½ knots, while at sea the ship had maintained a steady 13 knots. The result of the increased speed and power was a loss of 300 tons deadweight. That was more important than an extra ¾ knot, which could not be used in service.

Mr. J. A. Milne felt that the actual resistance of the trip wire itself could account for only a very small increase in the model resistance, and understood that the physical effect of the trip wire as a resistance, and not as a turbulence stimulator, was balanced by the laminar flow that could exist previously between the stem and the place at which the trip wire was fitted. Therefore, any increase of model resistance over and above that of the model without the trip wire could be attributed to stimulation of turbulent flow.

He agreed that the matter was one of urgency, and suggested that before condemning the principle of turbulence stimulation we should await more results, particularly those linking model with ship. He called attention to the position of the trip wire, the use of pins as a means of promoting turbulence, and urged further search until it was quite certain that we were getting 100 per cent turbulence.

Professor L. C. Burrill asked the critics of the present procedure of using a trip wire whether they would like to omit the trip wire and run the risk of having presented to them a result which was much too favourable.

As a propeller designer he pressed for the biggest clearance that could be provided between the propeller and the attendant structure, and would be sorry if the remarks made in the paper led to a resurgence of the opinions held in about the 1930s, when propellers were placed within about 4in of the posts and rudders. The results of that were vibration, erosion of the blades and stern frame, and bending causing rivets and bolts to become loose. There should be a clearance of at least 7 per cent of the propeller diameter between the trailing edge of the blades and the fin or nose of the stern post.

A matter about which we knew very little was the clearance above the propeller, and the evidence was that it did not seem of importance; but guidance on that problem would be worth while.

Referring to the question of the minimum diameter of the propeller in relation to breadth, Professor Burrill said that the diameter should be determined by the revolutions in relation to the power that was to be used.

The remarks about aerofoil propellers and ordinary round back propellers prompted Professor Burrill to say that in the merchant ship field there was a gain for the aerofoil propeller, in view of the low resistance of the section, and that gain applied over all sizes. We had adopted a pitch reduction at the root and calculations would show that there was no difference in efficiency whether the pitch was reduced at the root by 15 per cent or increased by 15 per cent. With a pitch reduction the blade angles were set at low values and in fitting the propeller to the boss a lower pitch enabled the use of a wider section. Althougn calculation confirmed that there was no gain for a pitch reduction, he would not like to have sections of the root acting at a high angle of incidence and would continue to use the lower angle.

Professor Burrill thought that the term "quasi-propulsive efficiency" should be retained, despite its awkwardness; it represented a clear relationship between the thrust h.p. that we thought was coming from the propeller and the power we were putting into the propeller.

Sir Amos Ayre, in his reply, commented on Dr. Allan's remarks, and said there was nothing more important at present than that the utmost concentration should be given to correlation of model and full-size ship results. He agreed that the solving of the problem would take two years, but until we found out the linkage under the new conditions we were living in a condition of chaos. A feature which he believed would help the shipbuilder to take his part of the responsibility, guided by the results from the tanks, would be the essential provision of the e.h.p. curve with and without the trip wire.

Sir Amos said he did not think that the increase of 16 per cent in the predicted e.h.p. of a ship as the result of using a trip wire on the model was exceptional, and he had seen a reference to an increase of 20 per cent at the service speed of a particular ship in an American paper. However, he was prepared to think that the difference between the turbulent and laminar condition resulting in the measured resistance on the model, for the single-screw cargo ship, might be 10 per cent on the average.

As to propeller clearances he said that he had not made any qualification concerning the type of rudder. Regarding the clearance at the top of the aperture, he had mentioned that in the days of the cast iron propellers there was a certain clearance which, as a rule, prevented erosion, and that should point to the correct clearance.

Finally, he was still in favour of dropping the use of the term "Q.P.C."—"quasi-propulsive coefficient."

(*To be continued*)

Retirement of Mr. V. A. M. Robertson, C.B.E.

At the end of this month, after completing forty-two years in railway service, Mr. V. A. M. Robertson, the chief civil engineer to the Southern Region of British Railways, is retiring, to become a partner in the firm of consulting engineers, Sir William Halcrow and Partners. Mr. Robertson was educated at Dover College and the Crystal Palace School of Practical Engineering, and began his association with railways in 1909 when he was articled for three years to a consulting engineer to the old L.N.W.R. In 1912 he became an assistant to the new works engineer of the S.E.C.R. During the 1914–18 war he served first with the London Scottish and was in 1915 gazetted to the Royal Engineers. He was demobilised in 1919 with the rank of major, after having been awarded the M.C. and bar for carrying out bridge work under fire. Mr. Robertson rejoined the S.E.C.R. for a few months before he entered the service of the G.E.R. (later part of the L.N.E.R.) and became district engineer, Stratford, and divisional engineer (Southern Division) in 1921. In 1928 he was appointed civil engineer to the Underground Railways, a position he retained on the formation of the London Passenger Transport Board in 1933. The year after he was made chief engineer (civil) of the L.P.T.B. In 1939 he was again promoted and appointed engineer-in-chief, a position he held until November, 1943, when he resigned to join the Southern Railway. At the beginning of February, 1944, Mr. Robertson was appointed chief civil engineer of the Southern Railway, a post which he has held ever since. During his career Mr. Robertson has been responsible for the expenditure of some £110,000,000 on railway civil engineering work. The large projects for which he was responsible included the western extension of the Piccadilly line, the L.P.T.B. £45,000,000 new works programme, restoration of the bomb damage on the L.P.T.B. and S.R., &c. In addition to being a Past-President of the Institution of Civil Engineers, Mr. Robertson is a member of the Institution of Mechanical Engineers, the Institution of Electrical Engineers, the Institute of Transport, the American Railway Engineering Association, and a Fellow of the Permanent Way Institution. He was made a C.B.E. (Civil) in 1943 and holds the rank of Colonel in the Engineer and Railway Staff Corps, R.E. (T.A.).

The Washburn Tunnel, Texas

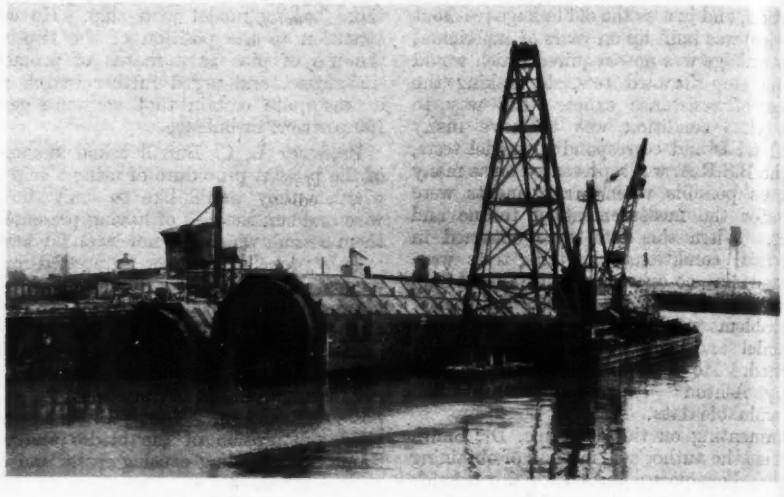
THE Washburn Tunnel, which is the eighth trench type of tunnel to be constructed in the United States, was opened to traffic recently. It passes under the Houston Ship Channel at Pasadena, Texas, and between grade points it has an overall length of 3791ft, comprising 1500ft of sunken steel tubular sections, 1436ft of concrete arched trenches and 855ft of open approach ramps. The top of the tunnel is 45ft below the mean low water level in the Houston Ship Channel, which has a navigable depth of 45ft. The maximum grade of the tunnel approaches is 6 per cent. The main tunnel structure consists of four tube sections, 375ft long and 35ft wide (shown at section AA in the accompanying illustration) and two transition sections, 12ft long and also 35ft wide. The double-shelled steel tubes have an internal diameter of 32ft and an outer octagonal shape of 35ft across the flats. The tube interior provides a roadway width of 22ft, accommodating two lanes of traffic, and a walkway and a fresh air delivery duct underneath the roadway. There is headroom of 13ft 6in in each lane; the central tunnel tube headroom is 18ft.

All the tunnel sections are fabricated and the four main sections were assembled at the yards of the Ingalls Shipbuilding Corporation at Pascagoula, Mississippi, in the same manner as any seagoing vessel. When launched, the tube sections, fitted with watertight bulkheads, slid down the ways on five 35ft sleds and, after balancing, were ready for being towed 400 miles through the Gulf of Mexico and the Inland Waterway to a dock at Galena Park, Texas, within 2 miles of the tunnel site. Our second illustration shows two tunnel sections at the Galena Park dock.

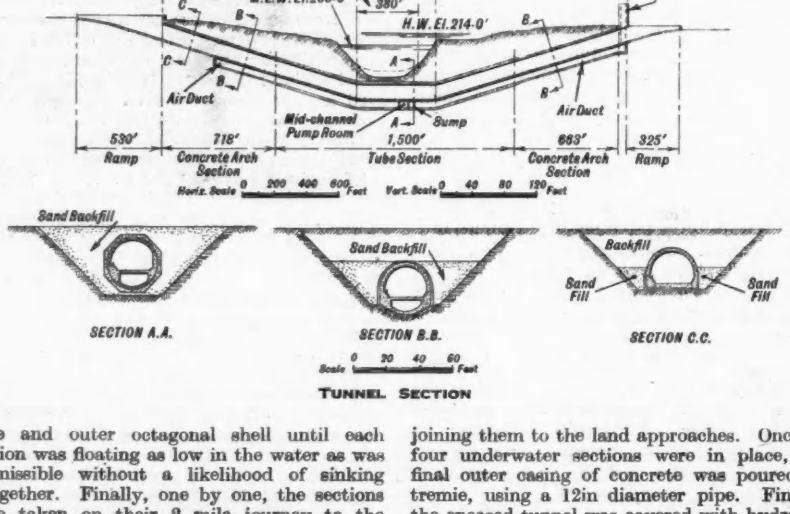
In the course of the "shape-up" work at the dock, the 375ft sections were fitted with circumferential reinforcing, a 2ft thick inner ring of concrete, a steel reinforced roadway, a walkway, ventilator ducts and conduits. All concrete was poured through temporary openings in the top of the tube section, later sealed by welded plates. Every pour had to be carefully timed and balanced to guard against overstressing the steel framework in any way. In the last pour at the dock, concrete was placed in the open space between the inner tube and outer octagonal shell until each section was floating as low in the water as was permissible without a likelihood of sinking altogether. Finally, one by one, the sections were taken on their 2 mile journey to the tunnel site, where, in the meantime, the contractor had dredged the 40ft wide channel-bottom trench to a depth of 90ft and had started construction of the approach sections of the tunnel. The four sections were brought into alignment above the trench and during the sinking operation a number of floating derricks maintained the sections in position. The joints between the individual tunnel sections consisted of knife-edges on one tube engaging in a gasketed groove on the mating tube, and were finally made water-tight by welding a channel ring across the gasketed joint. In order to sink the tunnel tubes to the bottom a carefully controlled amount of tremie concrete was gradually poured between the outer and inner shells, eventually producing a negative buoyancy of about 20 tons. Buoyancy of the water in the channel varied as the salt water content changed with every tide and allowances had to be made accordingly. The last pour caused the tube sections to rest on top of steel pile bents driven into the trench bottom to act as a temporary support until a bed of firmly packed sand could be placed beneath the tunnel. The gasket joint fittings locked each tube section to the next and, on either end of the span, to the transition sections joining them to the land approaches. Once all four underwater sections were in place, the final outer casing of concrete was poured by tremie, using a 12in diameter pipe. Finally, the encased tunnel was covered with hydraulic backfill.

Completing the tunnel interior, the temporary water-tight bulkheads at each end of each section were taken down. Subsequently the tiling was placed and the ventilation and illumination systems were installed.

The shore sections of the tunnel were built in open cuts with natural banks, except where the proximity of adjacent buildings necessitated provision of sheet piling for protection. A 4in sand blanket was laid at formation level for the width of the tunnel section, with keyways at intervals to resist the tendency of the tunnel arch to slide downhill. Membrane water-proofing, consisting of fabric and tar eight plies thick, was laid on this slab. A segment of the arch invert was then poured and cured. An inner travelling form was then erected on rails placed on the arch invert, the reinforcement was installed, the outer travelling form was moved into position and the main arch concreted in a single pour. The roadway haunches and slab, the kerbs, the pavement and the conduit casings were poured in subsequent, separate operations. On the south side, concreting was generally accomplished with a single-drum paving machine, transporting the concrete through an 8in concrete pump. On the north side, concrete was mixed in the same manner but placed by crawler crane and in addition some ready-mixed concrete was used. Ports in the outer forms permitted placing the concrete without excessive vertical drop. The concrete was vibrated through these ports to ensure a dense mixture being obtained despite the heavy reinforcement. After the arch concrete was cured, a water-proofing membrane was applied over the entire arch and protected with fibreboard insulation. The trench was then backfilled, using permeable material close to the arch, and spoil from the excavation for the remainder of the backfill.



TUNNEL SECTIONS AT THE "SHAPE-UP" DOCK



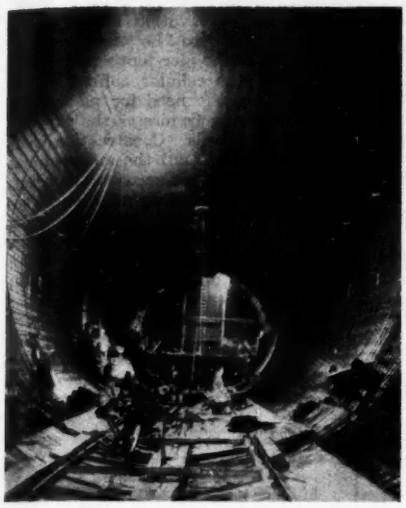
TUNNEL SECTION

The Washburn Tunnel has a fully automatic ventilation system, which provides a complete change of air every two minutes. Ventilation is supplied by three high-speed Westinghouse Sturtevant blower fans situated in the ventilation building at the entrance to the tunnel. Each fan has three speeds and provides nine stages of ventilation. Normally only five stages will be necessary to keep the tunnel air free from heavy concentrations of the carbon monoxide fumes discharged by motor vehicles. A maximum capacity of 760,000 cubic feet per minute is required and this can be supplied by any two of the fans. Automatic ventilation is obtained by two methods: the car count and the carbon monoxide analyser.

An electronic device keeps an automatic count of the cars in the tunnel at any time. This device is activated by quadruple light sources situated in the centre of the roadway just inside each portal of the tunnel. These lights consist of twin beams projected upward at a 45 deg. angle to photo-electric cells in the tunnel wall. A car entering the tunnel in either lane intercepts two of these beams, sending impulses to electronic counters. A car leaving the tunnel intercepts the same beams, only in reverse order. All the incoming cars at both ends of the tunnel are automatically

counted and added together. All of the outgoing cars are counted, added together and the total subtracted from the incoming cars. The result gives the exact number of cars in the tunnel at any given time and determines the stage of ventilation required.

The carbon monoxide method of determining the ventilation stage is based on continuous sampling of air, by an automatic analyser, at two points in the tunnel. These points are 300ft from each portal. Air samples are pumped to two carbon monoxide analysers, one situated in the ventilation building, the other in the south portal pump room. Here the air is humidified and passed through a catalyst cell. This process oxidises the carbon monoxide in the air stream and produces an increase in temperature proportional to the carbon monoxide concentration. A temporary rise in temperature generates an electrical potential in a thermocouple, which, in turn, operates a strip chart recorder. The recorder



PLACING INNER RING CONCRETE

measures the parts of carbon monoxide in 10,000 parts of air. Simultaneously it operates electrical relays, which control the fan speeds.

Provision has also been made in the design of the tunnel for a manual push-button smoke-control system. Tunnel guards, on detecting a car discharging excessive smoke fumes, possibly because of engine trouble, can push a button, which instantly steps up the speed of the fans to the next ventilation stage. The fans then operate at the increased rate for fifteen minutes and automatically drop back until their speed is altered by one of the other two control methods.

The fluorescent lighting system used in the Washburn Tunnel constitutes an improvement over those in earlier vehicular tunnels. Of the continuous slim-line type, the fluorescent lights turn on immediately upon pressing the switch. The light tube is less than ½in in diameter in contrast to the 1½in diameter of the conventional tube. In the event of power failure the tunnel has a standby lighting system. Lighting of the tunnel is graduated from a high intensity at the portals to prevent temporary blindness when the motorist enters the tunnel. Pumping stations are provided at each portal to handle rainfall from the open ramps and at the lowest point of the tunnel at mid-channel to handle any water accumulating from the seepage or washing operations.

Outgoing lanes of the tunnel gradually become wider at the end of each ramp, enabling outgoing cars to pass each other. Near the end of each ramp there is a traffic circle, which permits traffic to fan out quickly in various directions and prevents the congestion usual in the vicinity of older vehicular tunnels. The two traffic circles, facilitating flow of incoming and outgoing traffic, are part of the supplemental 7·4 mile access-highway system, which is now being completed. The Washburn Tunnel was designed by Palmer and Baker, Inc., of Mobile, Alabama, and built by the Merritt-Chapman and Scott Corporation of New York City.

Corrosion Resistant Materials

On February 13th a paper, entitled "Corrosion Resistant Materials," was read by L. W. Johnson, M.Met., and E. J. Bradbury, M.Eng., before the Institute of Marine Engineers and is summarised below.

The paper is divided into three main sections, which consider the theoretical aspects of corrosion, corrosive media and the corrosion-behaviour and properties of metals. The two principal forms of corrosive attack mentioned are direct chemical attack, such as oxidation and sulphidation in dry gases and electro-chemical attack, which is the usual form of corrosion in aqueous media and results from the formation of an electrolytic cell, in which the corroding metal is the anode. The corroding metal may be anodic to (1) another metal with which it is in electrical contact, (2) corrosion products in its own surface, and for this the corrosive media must be in contact with both the metal and the scale, and (3) chemical or physical inhomogeneities at the surface.

Discussed in the paper are particular corrosion phenomena including pitting, of which three examples are given, and dezincification or copper redeposition normally limited to brass. Intergranular attack, which can be expected only if the chemical or electro-chemical contrast between the grain interiors and grain edges is sufficiently pronounced, is mentioned and also stress corrosion, where the weakening effect of intergranular corrosion is more pronounced if tensile stress is applied, since the destructive effect is concentrated on a limited number of boundaries and cracking is propagated. Other phenomena are: (1) corrosion fatigue where, when alternating stress has produced corrosion cracking, any corrosive liquid can cause failure because the disarranged material formed along slip bands may be susceptible to attack; (2) impingement attack, which can be called corrosion erosion and generally occurs in pipe lines handling moving sea-water, the severity of the attack depending upon the speed of the water exceeding a critical value.

The authors list the four principle corrosive media encountered in marine engineering and state that they must be considered in conjunction with other factors. Fuels and their combustion products are discussed and reference is made to the effect of sulphur dioxide, which, when the temperature falls below dew point, dissolves in the condensed water to form highly corrosive sulphurous acid. Another danger is the high rate of corrosion possible, when ash with a high vanadium pentoxide content is in contact with metals at a temperature at which the components are liquid. The attack on steel occasioned by the presence of oxygen, acids, alkalis and calcium or magnesium salts is considered then sea-water attack is mentioned, followed by notes on the effect of various atmospheres.

The third section of the paper is devoted to the corrosion behaviour and physical properties of non-ferrous and ferrous materials. The non-ferrous alloys are subdivided into six classes: copper, copper-zinc alloys, copper-tin and copper-aluminium alloys, copper-base alloys, nickel-base alloys and aluminium alloys. Each material is discussed with regard to its corrosion resistant properties and its use for various parts of machinery. Comprehensive tables are included and they give the relative qualities of copper alloys in resisting different types of attack by sea-water, the physical properties of non-ferrous alloys, the resistance to impingement attack and the details of aluminium alloys for marine purposes. The ferrous metals are broadly divided by the authors into corrosion-resisting steels, heat-resisting steels and cast irons, the properties of each group being given in tabular form. The groups are sub-divided and the corrosion-resisting steels are classified into three main sections; martensitic, ferritic and austenitic, the comparative sections for the heat-resisting steels being 3 to 10 per cent chromium, 10 to 30 per cent chromium and austenitic. A number of cast irons, it is stated, have been developed to resist corrosive conditions and they include high silicon irons, high chromium irons, high nickel irons, "Ni-Resist," and "Nicrosilal." It is recorded that the magnesium process for increasing the strength of cast iron, by developing the spheroidal form of graphite, is being successfully applied to corrosion-resisting irons. The paper concludes with a section on metallic coatings in which hardness values of electro-deposited metals are given and also typical adhesion values of electro-deposited nickel.

A Pneumatic Gauging Equipment

Pneumatic gauging equipment has been developed for a wide range of special work by Solex (Gauges), Ltd., 223, Marylebone Road, London, N.W.1. Amongst the interesting instruments of this type recently designed by the firm was one for Vauxhall Motors, Ltd., which is used for checking seven dimensions simultaneously on cylinder liners. It indicates three internal and three external average diameters at different levels, and a measure of a liner's ovality.

As can be seen from the photograph we reproduce herewith, the equipment is arranged in a neat, well-finished cabinet in which the manometers used for checking are clearly visible through large windows on each side of the central gauging head. After a liner has been placed under a pneumatic ram above the gauging head, it is pushed down into the head by the ram and a small spring-loaded lever in the base of the head is moved to one side.

PNEUMATIC GAUGING EQUIPMENT FOR CYLINDER LINERS

When at the end of the gauging operation the lever is released and returns to its original position, the liner is drawn out of the head by a pair of claws arranged for automatic operation in the head of the ram. As it descends into the head the liner passes into an annular chamber formed between a spring-mounted gauging ring and a gauging plug. Both the ring and the plug have three sets of six measuring jets, each set being arranged on one of three common conduits and at different heights on the liner. The jets on each conduit are arranged at 60 deg. to each other and three inner and three outer sets give three average diameter readings.

A series of instruments are fitted to indicate to the operator that the unit is functioning correctly during the gauging of the liners. On the column above the gauging head are an

input air pressure indicator and a level indicator for the constant liquid level reservoir for the manometers. In a graduated tube, to be seen through a window on the bottom right-hand side of the instrument, the maintenance of constant pressure is indicated by two columns of liquid, and through a corresponding window on the other side of the head the reserve liquid level can be checked.

Three size-graduated manometer tubes behind a large window on the right-hand side of the unit are coupled to the air jets used for internal measurement purposes, and three similar tubes on the other side are coupled to the jets for external measurements. The size levels automatically zero to a horizontal line on the manometer scales during gauging, and any taper or other error in a liner is immediately indicated when the liquid levels in the scales do not correspond.

The instrument has been designed to operate in a straightforward way to give long trouble-free service whilst maintaining its accuracy. Air under pressure entering the unit passes into tubes dipped to a fixed length in water reservoirs, the excess air escaping by bubbling through the reservoirs whilst a rigidly fixed pressure is maintained in front of control jets connected to the respective manometer tubes. These control jets meter the amount of air delivered to each set of six measuring jets in the gauging head. It will be appreciated that the larger the outside diameter or the smaller the bore of a liner the smaller is the amount of air which passes through the respective measuring jets. A certain back pressure is thereby built up in the conduit to each ring of jets. This pressure pushes down the water levels in the manometers and the size of the liners is registered on the graduated scales. Conversely, if the outside diameter is small or the bore is large, a proportionately greater amount of air passes through the respective jets and the levels in the manometers do not fall so far. In this way inside and outside average diameters of a liner can be read off the manometer scales immediately a liner is inserted in the measuring head by the ram. The makers say that the inspection cycle for a liner can be as little as four seconds with a reading accuracy within 0·00002in.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

WROUGHT STEEL PIPE FOR THE PETROLEUM INDUSTRY

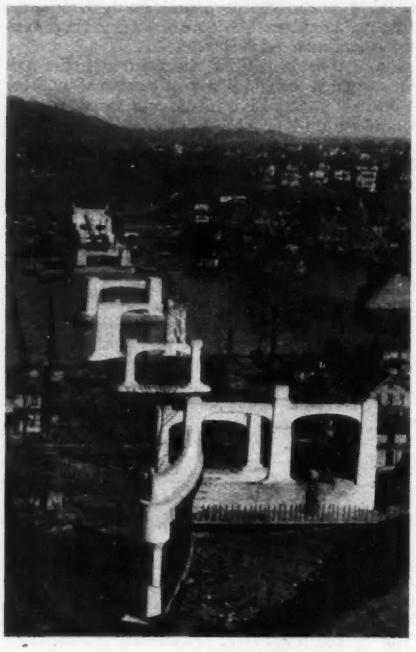
No. 1600–1607 : 1950. In this series, dealing with equipment for the Petroleum Industry, the British Standards Institution has issued B.S. 1600–1607, Wrought Steel Pipe for the Petroleum Industry.

This document comprises seven standards, as follows: B.S. 1600 Wrought Steel Pipe for the Petroleum Industry (dimensional requirements and permissible stresses); 1601, Electric Fusion-Welded Carbon Steel Pipe for use in the Petroleum Industry (sizes 4in up to but not including 30in); 1602, Electric Fusion-Welded Carbon Steel Pipe for use in the Petroleum Industry (sizes 30in and over); 1603, Electric Fusion-Welded Carbon Steel Pipe for High-Temperature Service in the Petroleum Industry (sizes 18in and over); 1604, Seamless Carbon Steel Pipe for High-Temperature Service in the Petroleum Industry; 1605, Seamless Carbon-Molybdenum Alloy Steel Pipe for High-Temperature Service in the Petroleum Industry; 1606, Seamless Chromium-Molybdenum Alloy Steel Pipe for High-Temperature Service in the Petroleum Industry; 1607, Seamless Alloy Steel Pipe for High-Temperature Service in the Petroleum Industry.

B.S. 1600 deals with dimensional requirements and permissible stresses and includes tables giving thicknesses for welded and seamless steel pipes, together with schedule numbers. The document has been prepared after careful consideration had been given to American Standards ASAB.36,10, Wrought Iron and Wrought Steel Pipe. Standards 1601–1607 incorporate chemical composition, mechanical properties and test requirements for the individual types of pipe and corresponding to the following standards of the American Society for Testing Materials: B.S. No. 1601 : ASTM-A139; 1602 : ASTM-A134; 1603 : ASTM-A155; 1604 : ASTM-A106; 1605 : ASTM-A206; 1606 : ASTM-A280; 1607 : ASTM-A15S. Price 10s. 6d. post free.

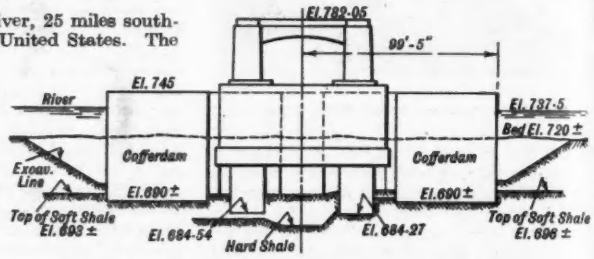
Construction of a Cellular Cofferdam

AN interesting cellular cofferdam design was used recently in the building of the two main river piers the Belle Vernon bridge across the Monongahela River, 25 miles south-east of Pittsburgh, in the United States. The 2000ft-long, four-lane highway bridge, which is now approaching completion, is part of a long-term project to link the Pennsylvania Turnpike with U.S. Route 40, enabling traffic between Ohio and the Turnpike to by-pass Pittsburgh. The substructure of the bridge, which is shown in the accompanying illustrations, consists of eleven concrete piers, four of them in the river. There is a large concrete abutment at each side of the river.



SUBSTRUCTURE OF BELLE VERNON BRIDGE

The underwater portion of each of the two main river piers consists of dual concrete shafts, founded on rock 70ft below river level. A concrete distribution block, 89ft long, 24ft wide and 38ft high, rests on the shafts and supports two rectangular columns, to which the structural framework of the bridge will be anchored. Both blocks are faced with North Carolina granite. A cross section through a main river pier is reproduced herewith. The columns on one of the river piers are 32ft high and 21ft high on the other. They are tied together at the top of each pier with a reinforced concrete member. The chief factor in the decision to use the cellular cofferdam for building the main piers was the 50ft depth from river level to rock and the additional 25ft excavation into the rock, which was thought to be necessary for placing concrete for the pier footings. Furthermore, the use of the cellular cofferdam construction eliminated the need for placing and later removing bracing frames as the pier construction moved upwards. Construction joints were placed as desired, and the enclosed area was always open, with free access to any part. The tops of the cells were also useful for storage of materials which were needed in constructing the piers. Each of the two main pier cofferdams consisted of six large steel sheet-piled cells, each with a diameter of about 52ft and spaced two on each side of the position of the bridge pier, and one at each end, and six smaller connecting cells. The connecting cells closed the spaces between the larger ones by forming convex walls of steel sheet piling with radii of 8ft or 11ft, as shown in the illustration below of the completed cofferdam. The six large cells and the six connecting small



CROSS SECTION OF SUBSTRUCTURE OF MAIN PIERS

CELLULAR COFFERDAM AND MAIN PIER OF BRIDGE

cells were filled with sand and gravel dredged from the river bottom, and the cofferdam was then pumped dry. A crane mounted on the cofferdam had free access to every part of it. One of the small connecting cells was driven 3ft lower than the others to serve as a flood gate.

CONSTRUCTION OF PIER PEDESTALS

The river bed was first dredged to remove any boulders or other debris which might hinder the driving of the piling. After dredging, a wooden template for one of the large cells was floated into position. The template was set in the correct position by triangulation from the river bank and the sheet piling was then pitched and driven to form a large cell. Upon completion of a cell, the template was removed and floated into position for the next large cell, whilst the first cell was filled with sand and gravel dredged from the river bed. When the six large cells were driven and filled, the six smaller connecting cells were driven. Each of the main pier cofferdams required 1000 "M-112" steel sheet piles, about 55ft long. The completed cofferdam was capped with approximately 6in of concrete to keep flood waters from scouring out the fill. It was also necessary to provide drainage holes on the inside face of the cells to keep the fill as dry as possible.

Shortly after the dam had been pumped dry air compressors and receivers were set up and the line drilling around the perimeter of the footings was completed. Blasting and excavation then followed, until the required depth below the rock surface was reached. All rock excavations came no nearer than 6ft to the cofferdam wall. The rock showed no sign of cracking or sliding during excavation but bracing was used as a safety precaution; the illustration above shows the excavation completed inside the cofferdam. Pressure grouting was used to stop the flow of water encountered at 13ft below the top of rock. After the pedestals were poured to a height of approximately 20ft above rock, backfill was placed around them and the 8ft thick footing slab was poured on top of the pedestals. The pier was faced with stone from the footing slab up to a height of approximately 30ft. From this point upward, each of the main piers consists of two separate shafts. Once the working level was above the waterline, the cofferdam cells were "hogged out" and the piling was extracted. It took about one month to construct a cofferdam and half that time to extract it.

The other two river piers, smaller in size, and the seven land piers, were built conventionally, with steel piling driven down to rock. Excavation beneath the river at the site of the main river pier cofferdams necessitated the dredging of 33,000 cubic yards of material. Approximately 14,000 cubic yards of concrete and more than 1450 tons of steel were used on the project altogether. The bridge was designed by the Pennsylvania Department of Highways; the substructure was built by the Dravo Corporation and the superstructure is being fabricated and erected by the Fort Pitt Bridge Works, both of Pittsburgh.

Continental Type Trolleybus for Glasgow

A BRITISH UNITED TRACTION single-deck trolleybus of a type new to operators in this country was inspected at Atherton recently prior to its delivery to Glasgow City Transport Department. The general design is based on the Continental practice of having a greater number of standing than seated passengers and is licensed to carry twenty-six seated and forty standing. It is a transit-type vehicle on which the passengers step on to a large platform at the rear, pass through the saloon and leave by a front exit.

Though Glasgow's trolleybuses, which are six-wheeled double-deckers, will carry seventy seated and ten standing passengers, it is only at peak hours that they do so. During the rest of the day they carry only about a third of that load. Therefore, whilst the single-decker has not quite the peak load capacity of the double-deckers, it will be able to handle the average traffic with lower running and maintenance costs.

The fare-collecting arrangement of this vehicle has been designed to facilitate the collection of fares during peak hours. On entering the bus at the rear, passengers continue into the saloon and pass the conductor, who is seated behind a lift-up pay desk against the rear bulkhead, so positioned as to enable him to see the gangway and platform. The passenger is then issued with a ticket from a machine fitted in the desk, so making it virtually impossible for the passenger to travel without tendering his fare. An advantage of the conductor's view of the platform is that, having control of the electrically operated two-panel folding rear doors, he can prevent possible step accidents, as the bus cannot proceed until the doors are closed. The front exit "Glider" doors act in the same way, but they are controlled by the driver, who has them under direct observation.

The signal to halt the bus can be given either by the conductor from his seat, or by any passenger by pressing bell pushes or a signal strip running the length of the saloon on either side. When a stopping signal is given, a panel in the front half-bulkhead behind the driver reading "Stopping," and a white light (by day) or a blue light (by night) in the driver's compartment. are both illuminated. Straps and handrails are conveniently disposed for the use of standing passengers. On this prototype a microphone is fitted at the conductor's desk, with loudspeakers in the roof to enable the conductor to give information or instructions to passengers.

The body, which is by Metropolitan-Cammell-Weymann Motor Bodies, Ltd., has an overall length of 30ft and a width of 8ft. The driver is separated from the passengers, in a full-height compartment, access to which is given by a sliding door from the saloon instead of the usual door on the offside, which is sometimes liable to lead to accidents from other traffic. All windows are glazed with safety glass, and there are five sliding windows provided on each side of the bus. Additional ventilation is given by six extractor ventilators fitted in the roof and an intake louvre at the front. The saloon is heated by electric tubular heaters which are under the control of the conductor, and situated behind the floor coving panels with suitable outlet ducts.

The chassis is a modified version of the 8ft wide model, RETB.1, designed by British United Traction, Ltd., as a 33ft long chassis for export, and is the first trolleybus of this kind to operate in Britain. To conform to the maximum British legal length the wheel base has been reduced from 17ft 6in to 15ft 7in, but the same overhangs of 6ft 7in at the front and 7ft 9in at the rear have been retained. Unlike the standard RETB.1 chassis, which has a straight-frame rear overhang, carrying one of the main electrical resistances, this prototype chassis has a drop-frame extension. The resistance is consequently mounted under the front overhang. Both this resistance and that carried in the usual position amidships are fully enclosed as a protection against the weather. Running on 10in by 20in tyres, singles front and twin at rear, the bus is fitted with Westinghouse air-pressure braking, using separate cylinders for each wheel. These cylinders operate directly on the brake camshafts through a short linkage fitted with mechanical adjusters.

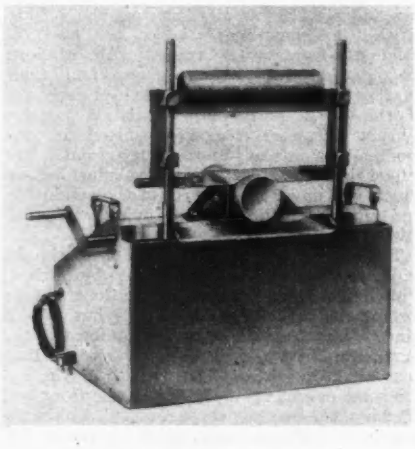
The contactor gear is housed in two metal-clad cases attached to the outside of the chassis frame member between the axles. Electrical equipment was supplied by Metropolitan-Vickers Electrical Company, Ltd., and consists of a 115 h.p. main motor, which drives through a heavy-duty rear axle with 9in worm centres. A system of automatic acceleration is provided, thereby ensuring that the transmission system and final drive are protected against excessive acceleration. A separate motor generator set is fitted, and battery manœuvring equipment enables the vehicle to be operated independently of the overhead wires.

COMMONWEALTH APPRENTICE TRAINING SCHEME.—The Brush ABOE group of companies has announced particulars of a scholarship scheme, which will permit engineering graduates from universities throughout the British Commonwealth to apply for apprentice training in this country. The scheme provides for two years' study of the methods employed in the group's factories, the first year being devoted to general training in basic manufacturing procedure and the second to more specialised instruction. A free return passage from the apprentices home to England will be paid, together with additional travelling expenses. Wages will be the same as those paid to other graduate apprentices at present working in the group's factories. Full details of the scheme are contained in an illustrated brochure, which has been prepared by the Brush ABOE Group, 32, Duke Street, London, S.W.1.

A Small Portable Hacksawing Machine

A NEW light portable hacksawing machine, which is now being manufactured by the Tungum Sales Company, Ltd., Painswick Road, Cheltenham, is illustrated in the engraving below.

This machine is designed to take 10in or 12in saw blades of the hand or machine type and to cut rounds, squares, flats, &c., up to 4½in. Its fabricated base of steel angles and plates encloses a ¼ h.p. electric motor which drives the saw frame through countershafts, pulleys and vee belts. The saw reciprocating motion is obtained from a crank on the last driven pulley, which is coupled to a sliding frame by a cast iron connecting-rod. This sliding frame is carried on four "Tungum" bearings, which move between substantial guide members in the main structure. A rigid saw frame is mounted on vertical pillars carried by the sliding frame. As the saw cuts through the work the saw frame slides down the support pillars. The saw blade is mounted on a slant in its frame with the leading end slightly higher than the trailing end. By varying the tension on the blade the rate of fall of the frame and hence the speed of cutting can be varied. When correctly adjusted the blade is kept clear of the work on the return stroke and automatically takes up the correct position to start cutting when the forward stroke begins.



SMALL SAWING MACHINE

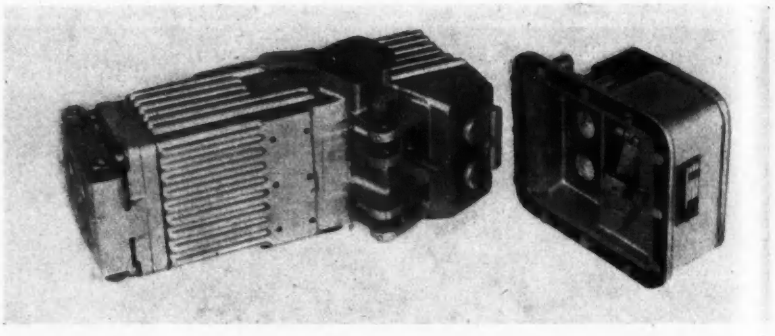
The work is held firmly between the jaws of a fabricated vice operated by a crank handle at one side of the machine. A support stand can be supplied with the machine for use when cutting up long lengths of material. In full working order the machine weighs only about 92 lb.

Aircraft Ground Starting Connector

WE have received recently from the Plessey Company, Ltd., Ilford, Essex, particulars of a heavy-duty ground connector. This equipment is suitable for connecting aircraft to ground-service trucks, particularly for engine starting, and so conserve the aircraft's internal power supply when the machine is grounded. The connector is available in 24V or 120V versions and is rated for a continuous current of 350A and for a peak of 1500A.

The two units which form the connector are shown in our illustration, the unit which is fixed permanently to the aircraft being the smaller. Attachment of the cable unit to the aircraft is effected first on one side by the elongated tongue and groove, which acts as a hinge, and is completed when the slam catch lever, which can be seen on the cable unit, engages with the catch plate on the fixed unit. Whilst engaging with the catch plate, the slam catch lever compresses a spring situated behind a hinged cover in the fixed unit, which serves to assist the disengagement of the two components upon the displacement of the thumb trigger release.

The dome butt contacts are tipped and in the cable unit are spring loaded. When airborne, the aircraft unit is fully pressurised. In this unit there is incorporated an electrical interlock which, operating in conjunction with the aircraft relays, ensures that the main contacts are only "live" when the two units of the connector are fully mated. The outlet of the cable unit is set at an angle of 25 deg. to the aircraft mounting to provide a convenient run for the heavy cable.



CABLE AND FIXED UNITS

A Vehicle Computer

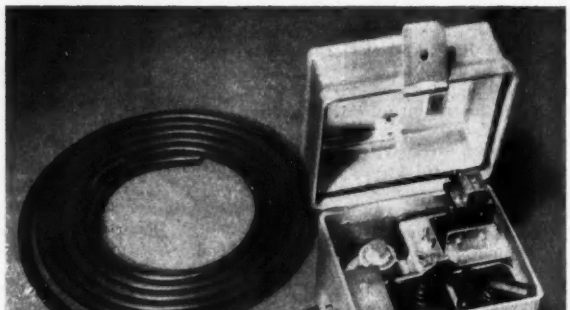
A SIMPLE form of vehicle computer designed for recording traffic flow has been developed by W. R. Sykes Interlocking Signal Company, Ltd., in conjunction with the Road Research Laboratory of the Department of Scientific and Industrial Research. The computer, which is illustrated herewith, is marketed by the Westinghouse Brake and Signal Company, Ltd., York Way, King's Cross, London, N.1.

The equipment consists of a road tube which is laid across the traffic lane and is connected to the computer itself, which is intended to be chained to a lamp standard by the side of the highway. When in position the tube is secured to the road surface by cleats and nails. One end of the road tube is pressed over a nozzle projecting from the left-hand side of the computer casing; the other end is fitted with an air release vent which must be kept free from dirt. Every time the wheel of a vehicle passes over the tube a pulse of air enters the computer. Although the pulse is of short duration it is enough to operate a metal diaphragm carrying a contact which closes a circuit through an electromagnet for driving a mechanical counter. Each pulse drives the counter spindle through 18 deg.; two pulses, therefore, turn the spindle through 36 deg., which represents an advance of one digit on the counter.

The computer, which is battery operated, is designed to accommodate either a 45V battery when the computer is used on a highway carrying fast traffic, or a 12V battery in other situations. It will be appreciated that the process of recording a very fast moving vehicle, which may give a contact of only 6 milliseconds duration, demands extremely rapid saturation of the electromagnet—a condition which is attained by using the 45V battery. The "on load" voltage under such conditions is only of the order of 9V and it is, therefore, important that a battery of small capacity should be used.

A switch mounted centrally in the computer, as shown in our illustration, allows the battery to be disconnected when the computer is not in use. A spark-quenching unit is incorporated to protect the contacts. To the left of the battery switch is a knurled knob whereby the contact opening on the diaphragm unit can be adjusted. A simple locating device checks movement of the knob at each 9 deg. interval; rotation through 9 deg. alters the contact opening by approximately 0·001in. The optimum contact setting can be determined by tests on site; the value is likely to be between 0·008in and 0·012in. Reducing the contact gap improves the sensitivity at the expense of an increase in the liability to over-count. On the other hand, a course setting, although suitable for heavier vehicles, would probably fail to register pedal cycles.

The computer is housed in a cast aluminium weatherproof case, fitted with a hinged lid and a carrying handle that is folded flush with the top of the lid for convenience when stacking. The counter, which is a six-digit non-resetting unit, can be seen through a perspex covered window in the lid.



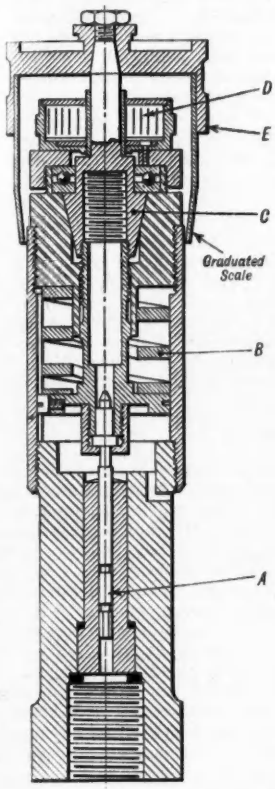
SYKES VEHICLE COMPUTER

A Fuel Peak Pressure Indicator

A SHORT while ago an indicator for oil engine cylinder peak pressures of up to 1500 lb per square inch, and made under Sulzer Patents, was introduced by Dobbie McInnes, Ltd., of Broomloan Road, Glasgow. This firm has now placed on the market a similar instrument for measuring fuel injection peak pressures up to 15,000 lb per square inch. The new instrument, which provides a means of obtaining an early warning of choking occurring in an atomiser, can be quickly and easily connected to a fuel

line by a simple automatic cock. Where multi-cylinder engines are concerned one of these cocks can be fitted to each line so that a single indicator can be used and transferred from cock to cock.

The design and operation of one of the new indicators can be followed with reference to the drawings reproduced herewith. As the body of the indicator is screwed on to the cock the lower end of the plunger *A* is forced up by the pressure in the fuel line. Under this fuel pressure the plunger, which is loaded by the calibrated spring *B*, lifts the conical nut *C*



ARRANGEMENT OF PEAK PRESSURE INDICATOR

off its seat. During the first injection cycle the conical nut is returned to its seat by a clock spring *D*, and its rotation is indicated by a graduated scale on the thimble *E*, which turns with the nut. During the second injection cycle the plunger, which has been locked in the up position by the nut, rises a little more and is again locked by the nut. The movement and locking of the plunger is repeated over a few cycles until thimble rotation ceases, when the maximum pressure in the fuel line is indicated on the scale.

The thimble is graduated to indicate pressures from zero to 10,000 lb per square inch in increments of 100 lb per square inch, and for pressures up to 15,000 lb per square inch it makes another half turn.

960 H.P. Diesel-Electric Locomotives for Siam

THREE 960 h.p. diesel-electric locomotives for long-distance service on the metre-gauge Siamese State Railways have been constructed at the Winterthur works of Sulzer Brothers. One of the new locomotives can be seen in the illustration below undergoing trials in service in Switzerland. The locomotives have been built to haul main line passenger trains between Bangkok and the Malayan frontier, a total distance of 1250 miles, and on which there are gradients up to 1 in 50. Trains will also be hauled on the 465-mile north-eastern route from Bangkok to Chiengmai, where gradients of 1 in 42 and 1 in 37 are encountered. These trains will have their loads limited to 250 tons. Throughout the Siamese railways train speeds are limited to 65km per hour (40½ m.p.h.) and axle loading to 12 tonnes.

The locomotives were designed by Sulzers, the mechanical portions being built by Henschel and Co., and the electrical transmission by the Oerlikon Company.

The leading particulars of each locomotive are:

Empty weight	55·0 tonnes
Weight in full working order	59·2 tonnes
Minimum adhesion weight	44·6 tonnes
Maximum axle load	12·0 tonnes
Starting tractive effort	14,000kg
Tractive effort (continuous rating)	5,800kg at 31 km.p.h.
Tractive effort (one-hour rating)	8,000kg at 22km.p.h.
Tractive effort available at full power and speed	3,000kg at 65km.p.h.
Wheel diameter	914mm
Bogie wheelbase	3·00m
Pitch of bogie pivots	7·80m
Length over buffer beams	12·80m

The fabricated bogie frames are supported on S.K.F. roller-bearing boxes through overhung laminated springs, the springs of the outer and centre axles on each bogie being compensated on each side.

The pressure-charged oil engine is set to give 960 b.h.p. at 850 r.p.m. at one-hour rating, and 860 b.h.p. at 800 r.p.m. continuously.

This engine is mounted on a common welded-steel sub-frame with the Oerlikon main generator, which has continuous ratings of 800 r.p.m., 1000V, 550A and 800 r.p.m., 630V and 860A. The generator one-hour rating is 800 r.p.m., 497V and 1070A, and its maximum load is 850 r.p.m., 1060V and 1680A. The 33·7kW overhung auxiliary generator supplies current for main generator excitation, and for driving the cooling water pump, radiator fan, exhauster, air compressor, rotary voltage converter, and for battery charging. Four self-ventilated, nose-suspended traction motors are grouped in parallel, and their ventilating air is drawn through ducts leading from the drivers' cabs. This arrangement has been adopted to ensure clean ventilating air, free from track dust and water, and provide continuous ventilation of the driving compartments.

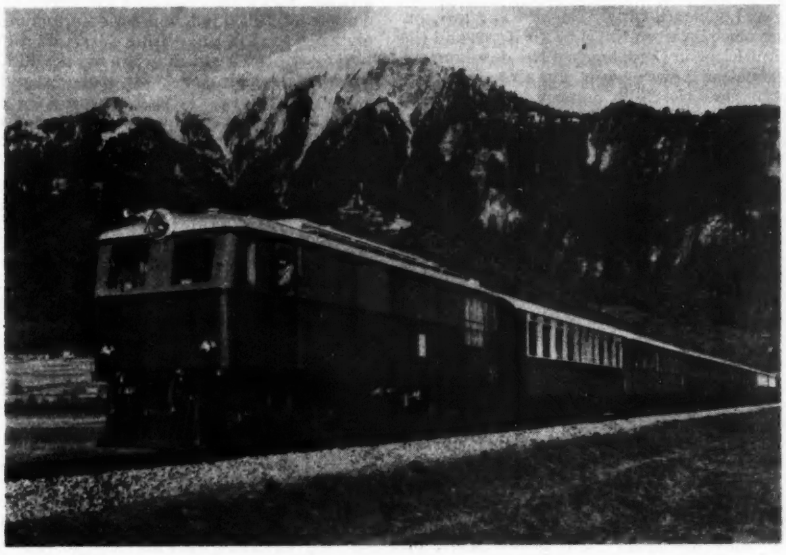
Through automatic field regulator control the driving controller influences the oil engine governor to set the engine speed to certain predetermined values. There are eight speed-torque loadings from 470 to 850 r.p.m. and from idling to 960 b.h.p.

NEW WIND TUNNELS.—A wind tunnel, stated to be designed for high-speed work, has recently been opened at the Vickers-Armstrongs works, Weybridge, Surrey. A larger wind tunnel for investigations at lower speeds is now under construction.

South African Diesel Mine Locomotives

THE first of a new design of diesel mine locomotive was recently completed by Hunslet Africa (Pty.), Ltd., of Cleveland, Transvaal, for a Free State gold mining company. Known as the Hunslet "Winner," it is a 5-ton locomotive of 34 h.p. and it will be put to work in development ends on heavy tramming duties. Twenty-four locomotives of "Winner" design are at present under construction at Cleveland for 2ft., 2ft 6in, and 3ft rail gauges. They are the first diesel units for heavy tramming work to be designed and built in South Africa by a British locomotive builder.

The "Winner" locomotives have a length over buffer beams of only 7ft, the overall width for 2ft gauge is 3ft 1in, and the height above rail level is 4ft 6½in. The locomotive has two speeds of up to 4½ m.p.h. and 8 m.p.h. in either direction. Speed and direction of travel are controlled by a single lever, which automatically ensures that, when changing gear the main clutch is fully released and the shaft brake brought into effect at the appropriate time. With the exhaust gas conditioner fitted, it is possible to obtain a high degree of scrubbing of the small quantities of noxious gases emitted, so that the contamination of mine air is kept down to the minimum.



DIESEL-ELECTRIC LOCOMOTIVE ON TEST RUN

Final drive is by coupling rods to the driving wheels. These rods are of heavy section and have bronze bushes working on hardened steel crankpins pressed into the cast steel wheel centres. Grease-gun lubrication is provided for the coupling rod bushes, the design being arranged to provide a reservoir of lubrication sufficient to meet the requirements of a shift.

The locomotive frames, cut from rolled steel plate, are exceptionally large for the size of locomotive, being of 2in plate with 2in footplates, 2in plate cross stays and 1in plate cross stretchers and having heavy section horn stays and stiffeners. Components such as bulkheads and fuel tanks are all of robust construction. The 4in diameter axles are carried in bronze axle boxes with lubrication from the oilwells in the keeps. Coupling rod drive has been carefully designed to give ample clearance and the rods are kept well above the path cleared by the buffer beams.

Special attention has been paid to braking, all sections of rods and levers being so designed that deflection under load is eliminated, thus enabling adjustment to be easily maintained and a high leverage to be used to the fullest effect.

American Engineering News

(From our American Correspondent)

Atomic Power for Aircraft

A recent announcement by the U.S. Air Force and the Atomic Energy Commission indicates that the first phase has been completed of a project known as "N.E.P.A."—the initials standing for Nuclear Energy for Propulsion of Aircraft. American investigations in this field go back to 1948, when the Massachusetts Institute of Technology conducted a study on behalf of the Atomic Energy Commission. The Institute's Lexington Report has never been published, but it is known that an aeroplane driven by nuclear energy was considered a theoretical possibility. The project now completed was concerned mainly with initial design computations and was undertaken jointly by ten aviation and engineering companies, the Fairchild Engine and Airplane Corporation, of Hagerstown, Maryland, being the principal contractor. The next phase of this project is expected to be conducted by the gas turbine division of the General Electric Company at Lockland, Ohio. Negotiations are now taking place between the U.S. Air Force and the General Electric Company for the development of a nuclear power plant for aircraft. It is thought that the B-36 bomber is likely to be employed as the first American experimental aircraft to be powered by atomic energy. The fuel load on a B-36 for maximum range is approximately 100,000 lb. In addition, the ten engines of the bomber have a total weight of about 50,000 lb. Thus, the nuclear power plant could be allowed to weigh up to 150,000 lb in replacing the conventional engines and fuel supply of the aircraft. It has been estimated that a B-36 bomber, driven by nuclear energy, could fly 2,000,000 miles on 1 lb of U-235.

Aluminium Helmets for the U.S. Army

A new 3 lb helmet assembly, consisting of an aluminium shell and a shock-resistant plastic liner, has been designed by the Quartermaster Corps of the U.S. Army and is about to go into limited production. It has been announced that the aluminium helmet is 15 per cent lighter and gives better protection than the present headgear. The plastic liner, on account of its great impact resistance, rather than the metal shell, will be the part of the helmet to stop bullets and shell fragments. The outward appearance of the helmet assembly is also being changed. It will be slightly higher in front to afford greater vision and low in the back to protect the wearer's skull and neck.

Crystal Amplifier for X-ray Inspection

An interesting development in the field of industrial X-ray inspection has been announced by the General Electric X-Ray Corporation, of Milwaukee, Wisconsin. The company has evolved an X-ray crystal detector system based on a semi-circular crystal of cadmium sulphide, which can be grown with linear dimensions from a fraction of a millimetre to several millimetres. When excited with radiation, the crystal acts as an amplifier valve, producing an electric current, which is used to operate various indicating mechanisms. It has been found that such cadmium sulphide crystals amplify the energy they receive 1,000,000 times. On an area-for-area basis they are claimed to be over 1,000,000 times more sensitive to X-rays than the ionisation chambers, which are commonly used for the measurement of such radiation. In addition to their sensitivity, the crystals are stable and respond instantly to variations in the intensity of X-rays. A prototype installation of the crystal detector system is about to be delivered for a test on an ordnance production problem, and pilot laboratory models have been built to inspect the product level in soup and beverage containers, and the continuity of the powder trains used in blasting fuses. The high sensitivity of the cadmium sulphide crystals allows the use of X-rays of comparatively low intensity. Thus, in the case of the inspection of blasting fuses a small X-ray unit was employed, operating at 20kV and 1mA. It was possible in that particular application to detect a $\frac{1}{4}$in void in the powder train inside a $\frac{1}{4}$in diameter cord, with the fuse moving at the rate of 60ft per minute. The current derived from the crystal passes through a relay circuit, which in turn may be arranged to stop the production line operation involved should a faulty product be encountered. So far, the crystals employed have been small, but in case of future needs to integrate larger inspection areas the crystals may be grown to larger sizes; furthermore, batteries of crystals may be built up opposite the X-ray tube.

A Lightweight Helicopter

The "Hiller-Hornet" helicopter, which has been designed and will be manufactured by Hiller Helicopters, Inc., of Palo Alto, California, has now reached the production stage. Originally, it had been planned to market the aircraft, which has a weight of only 356 lb, in the United States for less than 5000 dollars, but as the U.S. Army has decided to take the entire output of the works no helicopters of this kind will become available to civilians for the time being. The aircraft has two rotor blades, which, when extended, form a single blade 23ft long. At each outer end is attached a ram-jet engine having a weight of only 11 lb. The engine units are said to be replaceable within two or three minutes. On account of its heavy fuel consumption the range of the aircraft, as developed at present, is relatively short. According to the manufacturers, it is able to fly for a period of forty-five minutes at its cruising speed of 70 m.p.h., giving it a range of approximately 50 miles when two persons are carried. Its top speed is stated to be 80 m.p.h. The operational life of the power unit has been estimated at 500 hours. The helicopter has performed climbs at the rate of 1100ft per minute and has a ceiling of 12,000ft. Its fuselage is 11ft long.

Bridging the Straits of Mackinac

A bridge across the Straits of Mackinac has been pronounced feasible both from a physical and an economic point of view, according to a report which has been submitted by the Mackinac Bridge Authority to the governing body of the State of Michigan. The Straits of Mackinac connect Lake Huron and Lake Michigan and are approximately 5 miles wide at the point where it is proposed to construct the bridge. The major structure involved is a suspension bridge having a 3800ft main span and two 1500ft side spans. To permit the largest lake vessels to pass, the minimum vertical clear height at the centre of the span would be 150ft. The approaches to the suspension bridge will consist of twenty-two truss spans varying in length from 302ft to 560ft and four spans close to each shore having lengths of between 160ft and 200ft. The towers of the suspension bridge would have a height of 565ft above water level, and the support cables required would be approximately 25in in diameter. Initial plans for the structure are based on a bridge carrying two lines of traffic in each direction. It is of interest to note that, while the estimated cost of construction of the bridge is 76,300,000 dollars, the cost of construction of a similarly sited vehicular tunnel to carry the same traffic has been estimated to be 141,000,000 dollars.

Manufacture of British Jet Turbines

The Buick Division of the General Motors Corporation has received a 25,000,000 dollar contract for the production of the Armstrong Siddeley "Sapphire" turbo-jet engine. Manufacture of the engines will take place under licence from the Wright Aeronautical Division of the Curtiss-Wright Corporation, the holder of the American patents of the "Sapphire." The engines will be employed to power the Republic S-84-F "Thunderjet" aircraft, which will be built by General Motors at an assembly works in Kansas City.

French Engineering News

(From our French Correspondent)

French cement production in 1950 was 7,900,000 tons. The best pre-war year was 1932 with 5,700,000 tons and the best post-war year 1949 with 6,700,000 tons. The 1950 figure given above includes the Saar, French production alone being 7,200,000 tons. France has 300 cement manufacturing concerns, employing 16,000 workers.

* * *

An International Congress on Internal Combustion Engines will be held in Paris between May 7th and 19th. About 100 papers will be read during the first week of the Congress, and visits have been arranged to large industrial plants. About fifteen countries have accepted invitations to attend.

* * *

A scheme has been prepared for the electrification of the Valenciennes-Thionville Railway. This line provides an important means of communication between the French iron and steel industry and German industrial areas, and it is hoped that electrification will improve the transport of coal and ores. It is planned that the French line would be electrified first from Valenciennes to the German frontier, via Thionville, and later the Germans would electrify their section of the line from Coblence to the French frontier, via Treves. If this electrification is carried out it will be the first electrification on either the Northern or Eastern sections of the French Railways.

* * *

Discussing the development of French tractors and other plant used in civil engineering, Monsieur Pommier told the Syndicat Général des Industries Mécaniques that French construction methods had improved and that output was far greater than that obtaining before the war. The greatest progress has been made in the construction of heavy machines; for example, draglines with buckets of 3 cubic metres capacity were being used on the Donzère-Mondragon project. He also said that France was now in a position to export mechanical excavators in large numbers. France was also constructing 150 h.p. tractors, and progress had been made in the construction of rollers for road construction.

At the same series of meetings, Monsieur Derache spoke of mining plant and said that France had about seventy manufacturers of mining machinery. The Charbonnages de France took about 85 per cent of their production, while the other 15 per cent went to non-nationalised mines. Since the end of the war they had played an important part in the modernisation of French mines under the Monnet Plan, so that nearly all the plant necessary for the smooth working of the French mines was of French construction. Unfortunately, the rate of production had already dropped by about 30 per cent, and it looked as if this reduction would continue. This was not surprising, following the tremendous effort made to re-equip the mines between 1945 and 1950. Owing to French demands, however, no effort had been made to export up to the present. Finally, Monsieur Derache said that the industry would also concentrate on standardisation and simplification.

Tasmanian Railways

THE Government-owned railways system of Tasmania, which even the kindliest observer could only describe as obsolescent, is to be given a new lease of life. The authorities have planned to expend £A3,500,000, to be spread over the next few years and to be devoted principally to improvement and regrading of the permanent ways and some electrification of suburban services. It is also hoped that some replacement of the older rolling stock will be embodied in this scheme. In point of fact, the impact of motor transport has tended to make the railway system of the island a losing proposition and its ultimate scope would appear to be strictly limited.

Industrial and Labour Notes

Non-Ferrous Scrap Prices

The Minister of Supply has made the Non-Ferrous Metals Prices (No. 2) Order, S.I. 1951, No. 425, to overcome certain anomalies in scrap metal trading and to remove difficulties which have prevented the free flow of non-ferrous scrap to industry in recent weeks.

The Order, which came into operation on Saturday last, March 17th, makes the following provisions: The maximum commission for merchants on material other than lead is increased from 2 per cent to 3 per cent; the maximum charge for bagging is increased from 9d. to 1s. 6d. a bag, or £1 5s. a ton, whichever is less; a charge for briquetting not exceeding £1 5s. a ton is authorised; the basis of lead prices is changed from "delivered buyer's address" to "ex depot," with the proviso that when lead material is delivered by the seller the charges for delivery shall not exceed £2 per ton; provisions relating to invoices have been amplified, and a number of definitions have been clarified.

The Order also authorises price changes for certain categories of non-ferrous scrap. New prices per ton of copper scrap range from £180 to £190; of lead from £119 to £125; of cupro nickel from £180 to £220, and of brass from £159 to £175. It is stated that the Order was made after full consultation with the many trade interests concerned.

Wage Incentive Schemes

A pamphlet dealing with wage incentive schemes has just been published by the Ministry of Labour as a supplement to its Industrial Relations Handbook. The pamphlet gives particulars of various systems of payment by results, and has been prepared with the co-operation of the National Joint Advisory Council in the hope that it may be of assistance to those responsible for wage questions in industry.

As pointed out in a foreword to the pamphlet, the need for reduced costs of production and increased output has become even more urgent in view of the diversion of a substantial portion of the labour force to the carrying out of the Government's defence programme. But it is also pointed out that reduced production costs need not mean a smaller wage packet; in fact, earnings can be increased where they are associated with increases in industrial output by means of wage-incentive schemes. As the pamphlet emphasises, however, it is essential that wage incentive schemes should be well designed and suited to the circumstances of the particular industry and even of the individual firm, so that they may result in the desired increase in output or efficiency. They should ensure, the pamphlet observes, that the additional earnings resulting from the operation of the schemes are closely related to the extra effort which the worker has been called upon to make to achieve increased output.

At the same time, the foreword to the pamphlet concludes, a fair day's work for a fair day's pay remains the soundest basis for relationships between employers and workers, and incentive schemes must not be regarded as a substitute for that basis. So long as that is understood, however, in establishments or industries where some revision of existing methods of production or wage systems can secure a properly enhanced rate of output and an increase in workers' pay packets corresponding to their extra effort, wage incentive schemes will benefit the nation as a whole and give mutual advantage and satisfaction to the employers and workers concerned.

The Railway Executive and the Railway Unions

When a settlement on wages was reached, on February 23rd, between the Railway Executive and the three railway unions, an undertaking was given by the unions concerning the imperative need of the fullest co-operation in eliminating the waste of manpower, increasing efficiency and improving productivity within the railway industry. It was also agreed that a joint manifesto signed by the Executive and the three unions should be issued to the staff of British Railways asking for the fullest support in the "great tasks ahead."

That manifesto was circulated to railwaymen at the end of last week. It contains full details of the new rates of wages—which were retrospective to January 1st—for all grades of railway workers and staff, and explains that the effect of the increases will be to add £12,000,000 to railway costs. "Because," the manifesto says, "only a part of the extra £12,000,000 to be spent on wages and salaries can be recovered from savings effected under nationalisation, it means that in order to find the money, passengers and senders of goods by rail will be asked to pay more." The more that people have to pay for railway transport, the manifesto emphasises, the more critical they will be of the service they get for their money, and the more they are likely to think twice before using the railway at all. The staff of British Railways is therefore urged to do its utmost to give the best possible service and so help the national railway system to carry the burden of extra costs.

The manifesto goes on to say that there are many improvements in service and schemes for reducing working costs which the Railway Executive would like to restore, or is now able to plan as a result of nationalisation, and which if carried out would greatly help the efficiency of the railways. The smooth and effective introduction of such proposals, it is stressed, depends to a large extent on the co-operation of the trade unions and the staff at all levels. The manifesto therefore urges all members of the staff to bear in mind that the opportunities for reorganisation and technical progress must be given full scope if the railways are to continue to progress.

The T.U.C. and Arbitration

In the current issue of *Labour*, the monthly journal of the Trades Union Congress, Sir Vincent Tewson, the general secretary of the T.U.C., has commented on demands advanced by various sections of the trade union movement for the withdrawal of the Conditions of Employment and National Arbitration Order, 1940. It was generally appreciated, he says, right through the war, that conditions were such as to necessitate the retention of the Order and the review made annually by the T.U.C. general council usually took the form of making suggestions as to its methods of working. When the war ended the Order was retained on the understanding that the question of its continuance could be raised at any time, and it has been subject to annual review by the general council.

From the beginning, Sir Vincent says, it was realised that, to have any real standing, that part of the Order which prohibited strikes and lock-outs required penal clauses, and the existence of those penal clauses has been known by everyone capable of expressing an opinion on the operation of the Order. Strikes and lock-outs are illegal under the Order, but, Sir Vincent comments, it is true that unofficial stoppages have taken place without prosecutions ensuing. He goes on to observe that unofficial agitations have occurred regarding the termination of the Order, but affirms that the T.U.C. general council does not determine policy in the light of unofficial demonstrations. Nevertheless, Sir Vincent argues, different conditions require different treatment and the general council feels that, in the new position which has developed since the formal termination of wage restraint policy, the matter has to be reviewed.

Sir Vincent reiterates that the T.U.C. general council will never be stampeded by unofficial action but, he says, it now feels it to be its duty to suggest to the Minister of Labour alterations in the Order, "which will enable reliance to be placed on the good sense of the trade unions." The general council's proposals on the matter, Sir Vincent declares, are not a turning down of the principle of arbitration; they are intended as an incentive to the development of machinery such as that which is to be seen "in the mining and other industries, where arbitration is part of the collective bargaining machinery."

Employment and Unemployment

The Ministry of Labour's latest report on the employment situation in Great Britain states that, during January, the working population increased by 22,000 (20,000 men and 2000 women) and at the end of the month numbered 23,247,000 (15,941,000 men and 7,306,000 women). The size of the forces increased during January by 21,000 to a total of 773,000. The number in civil employment rose by 19,000 to 22,164,000 (14,979,000 men and 7,185,000 women).

At the end of January manpower in the country's basic industries numbered 4,158,000, a net increase of 5000 during the month. The principal addition in these industries was in coal mining, the number of wage earners in colliery books being 696,000, compared with 689,000 at the end of December. The gas, electricity and water industries added 2000 to their labour forces during January, but there was a drop of 1000 in the number of people employed on transport and communications and a drop of 3000 in the number employed in agriculture and fishing. The net increase in January in the labour forces of the manufacturing industries was 39,000, the total employed in this group being 8,659,000. The biggest addition, 23,000, was in the metals, engineering and vehicles trades, in which by the end of January, 4,109,000 people were engaged, compared with 3,969,000 at the end of 1949.

Statistics on unemployment, which were issued by the Ministry of Labour last week, show that on February 12th there were 301,952 people registered as out of work, compared with 333,571 on January 15th.

The Engineering Industry and Taxation

At the end of last week the Engineering Industries' Association issued a statement concerning representations which it has made to the Chancellor of the Exchequer on the 1951 Budget. The Association emphasises that a reduction in Government expenditure should be the principal means of maintaining a balanced economy and that savings in expenditure must be made to minimise any requirements for additional revenue.

The engineering industries, the Association points out, are being asked simultaneously to expand production for the Services, to maintain exports and to supply the home market. As taxation has been too high for many years, it has been quite impossible for most engineering firms to provide funds for expansion out of retained profits. If the taxation of industrial profits is again increased, the statement reads, the engineering industries may not be able to meet the enormous demands which will soon be made. There will not be enough money in the industries to finance new plant, more wages and bigger stocks.

The Engineering Industries' Association considers that any essential increase in direct taxation should be shared by all classes of taxpayers. Lack of wages control, it suggests, may cause additional taxation of earnings to become inflationary in its effect, but that possibility should not be an excuse for overtaxing industrial profits. The principal recommendations made by the Association are that taxation on profits retained in a business should be reduced rather than increased; that the basis of computation of taxation liabilities should be reformed as soon as possible after the report of the Millard Tucker Committee has been submitted, and that rearmament should be financed to a considerable extent by reduction in other forms of Government expenditure.

Notes and Memoranda

Rail and Road

SOUTH LONDON TRAM CONVERSION SCHEME.—On the night of April 7/8th there will come into effect the third stage of the scheme for converting the tram routes in South London to bus operation. This stage consists of the replacement of three tram routes by two new bus routes and will see the end of all tram services in Purley, Croydon, Norbury and Streatham, and a further reduction in services throughout Lambeth, Southwark and Westminster and along the Victoria Embankment. In this part of the conversion scheme ninety-two trams will be withdrawn and replaced by 106 buses, and 22 miles of tram tracks will be abandoned.

LARGE DIESEL-ELECTRIC POWER VANS.—Five diesel-electric rail vehicles, each of 1470 h.p., have been built by Sulzer Bros., Ltd., for passenger and freight train haulage on the Algerian section of the North African Railway, extending from Tunis to Casablanca. Each of these units consists essentially of a luggage van, 69ft 9in long, with two 735 b.h.p. oil engine generator sets in the centre. At each end van space is left for carrying light freight or luggage. An A1A-A1A wheel arrangement gives about 68 tons of adhesive weight out of a fully laden weight of 88½ tons. Designed for a top speed of 81 m.p.h., the units are capable of hauling a trailing load of 150 tons on the level at maximum speed.

Air and Water

SAMUEL BAXTER PRIZE.—£2000 has been left to the Institution of Naval Architects by the late Arthur William Baxter, the income of which is to be applied to an annual prize. It is to be called the "Samuel Baxter" Prize and given as a recognition for the best contribution during the year towards safety or efficiency in sea-going vessels.

THE "BRISTOL" F.2B FIGHTER.—The Bristol Aeroplane Company, Ltd., has just reconstructed and flown an aircraft, the prototype of which first flew in 1916. Despite long years of storage, only minor replacements were required to the frame or to the Rolls-Royce "Falcon" engine. The machine is the "Bristol" F.2B Fighter, which is to be used for display purposes.

RESEARCH SCHOLARSHIP.—A research scholarship of £400 per annum and tenable for two years has been offered by the Aluminium Development Association for research in the application of light alloys to ship construction. Full particulars of entry, which closes on June 30th, can be obtained from the Secretary, Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1.

B.E.A.C. CHAIRMAN.—The Minister of Civil Aviation has extended the term of appointment of Lord Douglas of Kirtleside as chairman of British European Airways Corporation until March 13, 1954. His original appointment, dated March 14, 1949, was for three years, and his term has thus been extended to cover a five-year period. The chairman of British Overseas Airways Corporation holds his office for a similar term.

Miscellanea

COMBUSTION ENGINEERING ASSOCIATION.—The Combustion Engineering Association has announced that, as this is the Festival of Britain year, it has decided to hold its next conference in May, 1952.

NUTS AND BOLTS PRICES.—The maximum prices of certain types of bolts, nuts, studs, screws and rivets have been increased from March 16th, under an Order made by the Minister of Supply. The Order (S.I. No. 404), which consolidates the previous Control of Bolts, Nuts, &c., Orders, covers all items specified in those Orders with the exception of aircraft, bolts, nuts and screws.

THE LATE MR. J. J. SAUTTER.—We have learned with regret of the death of Mr. John Jules Sautter, M.I.Mech.E., which occurred, after a long illness, at his home, "The Quest," Dartmouth Road, Paignton. Mr. Sautter, who was seventy-four, was managing director of Philip and Son, Ltd., of Dartmouth, the firm with which he had been actively associated for almost the whole of his working life.

B.B.C. TELEVISION STATIONS.—The Assistant Postmaster-General, Mr. Hobson, said last week, in reply to questions in the House of Commons, that the rate of television development had been reviewed in relation to the defence programme. It had been decided that the high-power stations at Holme Moss, Kirk o'Shotts and Wenvoe should be completed, but that the proposed five low-powered stations should be postponed indefinitely.

THE CHEMICAL RESEARCH LABORATORY.—The Department of Scientific and Industrial Research states that the Lord President has appointed Mr. D. D. Pratt, Ph.D., acting director of the Chemical Research Laboratory, Teddington, to be Director of the laboratory. Sir Robert Robinson, O.M., F.R.S., has accepted the invitation of the Lord President to act as an honorary consultant to the Director of the Chemical Research Laboratory on research in pure organic chemistry.

PRODUCTION ENGINEERING RESEARCH.—An illustrated lecture, entitled "Economic Advantages of Production Engineering Research," showing the economic gains that can be achieved by the co-operation of executives and production personnel in industry with the industrial research organisation, will be given by Dr. D. F. Galloway, Director of Research of the Production Engineering Research Association, on Wednesday, April 11th, at 7.30 p.m., at the College of Technology and Commerce, Leicester.

A NEW FILM PROJECTOR.—Last week G. B. Equipments, Ltd., 37-41, Mortimer Street, London, S.W.1, demonstrated its new model "621" 16mm projector, which supersedes the "601" model. This new unit follows closely the design of the earlier model, but, in addition to a modern "streamlined" finish, it incorporates drop-in spool arms, a prefocus exciter lamp, an improved sound head and a quick thread base cap, which facilitates and speeds projector lamp replacement. In a run with a test film the excellent qualities of both sound and vision given by the new projector were fully demonstrated.

INDUSTRIAL OPEN DAYS AT THE N.P.L.—The National Physical Laboratory at Teddington is arranging "open days" for industrial representatives on Monday and Tuesday, May 28th and 29th. These open days are intended to give an opportunity for scientific and technical workers in industry to see the scientific research work and special investigations undertaken at the laboratory. The laboratory will be open on each day from 10.30 a.m. to 5.30 p.m. and luncheon and tea may be obtained on the premises. Some tickets are being reserved for postal applications from accredited representatives of industrial organisations and those interested are invited to apply to the Director, National Physical Laboratory, Teddington, Middlesex, not later than May 8th, indicating on which of the two days they would prefer to visit the Laboratory.

TECHNICAL INFORMATION AND DOCUMENTS UNIT.—As from April 1st, the Technical Information and Documents Unit (T.I.D.U.), which for a number of years has been attached to the Board of Trade, is to become part of the information services of the Department of Scientific and Industrial Research. For the present the unit will remain at Lacon House, Theobalds Road, London, W.C.1, where it will continue to hold at the disposal of industry the large collection of unpublished documents, interest in which has recently revived on account of the valuable information they contain on the production and use of substitute materials. A small technical section is available to assist with the selection of material to meet specific needs, whilst a reading room is provided for those wishing to make a detailed study of drawings and documents. Alternatively, photo copies can be supplied at moderate charges.

FAN MANUFACTURERS' ASSOCIATION LUNCHEON.—The Fan Manufacturers' Association held a luncheon at the Connaught Rooms, London, on Thursday, March 15th. In proposing the toast of "The Guests," Mr. H. D. Mains, the President, mentioned that the Association's policy, to concentrate on technical development and to keep in close contact with the Government departments, had been maintained. It is realised that the competitive element is essential to industrial progress, and he said that the association had continued to resist the formation of any price ring. The president mentioned the various Government departments which consult the association and, referring to the effect of the rearmament programme, he said that it is hoped to assist members in securing adequate supplies of essential materials. He mentioned the reconstitution of several sub-committees, commented upon the activities and value of the national college, where a new laboratory was opened recently, and underlined the industry's need for young engineers. Replying on behalf of the guests, Mr. A. G. Griggs had something to say regarding the Worshipful Company of Fan Makers and presented a copy of its history to the association; Mr. J. W. Stitson gave some information concerning the Institution of Heating and Ventilating Engineers, and Mr. H. A. Secretan outlined the present position of the National College and its hopes for the future.

Personal and Business

MR. A. NEWING, A.M.I.E.E., managing director of Nevelin Electric Company, Ltd., has been appointed a director of Lancashire Dynamo Holdings, Ltd.

MR. B. JUBB, B.Sc. (Eng.), A.M.I.Mech.E., A.M.I.E.E., has been appointed sales manager of the instrument and meter section of Crompton Parkinson, Ltd.

EDGAR ALLEN AND CO., Ltd., Sheffield, announces the retirement of Mr. R. S. Brian, manager of the trackwork department. Mr. D. P. Carr has been appointed to succeed him.

TRINITY DESIGNS AND METHODS, Ltd., has been established at Grosvenor Gardens House, London, S.W.1, as a firm of technical consultants, tool designers and methods engineers.

COLTON ELECTRICAL EQUIPMENT COMPANY, Ltd., 198, Blackstock Road, London, N.5, is moving on May 1st to Cranham Hall Works, Moor Lane, Cranham, Upminster, Essex (telephone, Upminster 4454).

MELLOR BROMLEY AND CO., Ltd., Leicester, states that, following the death of Mr. T. C. Bromley, Mr. H. R. Backhouse has been appointed chairman and managing director and Mr. H. B. Cufflin has been elected to the board.

A. C. WICKMAN, Ltd., Coventry, announces the appointment of Mr. George Kelway as area manager in Birmingham, in succession to Mr. C. R. Perks, who is to manage a new factory being established by the firm at Mentone, Australia. Mr. Kelway has been on the staff of A. C. Wickman, Ltd., since 1932.

SILENTBLOC, Ltd., announces the formation in Australia of a company for the manufacture of its products. The new company is known as Silentbloc (Australia) Pty., Ltd., and has its headquarters at Doonside Street, Richmond, E.1, Victoria. Mr. P. J. de Steiger, M.I.Mech.E., has been appointed technical manager.

MR. ROBERT W. ASQUITH, M.I.P.E., has been appointed chairman of William Asquith, Ltd., Halifax, in succession to Mr. Lewis Rhodes, who has retired after fourteen years' service in that position. Mr. Rhodes will continue to serve as a director, and Mr. J. D. H. Horobin, secretary of the company, has been elected to the board.

TUBE INVESTMENTS, Ltd., announces that, following the release of Mr. A. G. E. Briggs, an assistant managing director, to serve as Deputy Controller of Supplies (Munitions) Production, Ministry of Supply, his responsibilities as managing director of Simplex Electric Company, Ltd., have been taken over by Mr. E. G. Plucknett, commercial director, and Mr. A. G. Jones, works director, who have been appointed joint general managers.

Contracts

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., are to build a bauxite ore carrier of 8000 tons deadweight for the Pan-Ore Steamship Company, Inc. The double reduction geared turbines and water-tube boilers will be constructed by David Rowan and Co., Ltd.

RICHARD C. GIBBINS AND CO., Ltd., Birmingham, has received a contract from the Wellington (New Zealand) Harbour Board for the supply of nine three-motor cage-operated electric overhead travelling cranes of 2 tons capacity, and one crane of 5 tons capacity. The total value of the contract is a little over £25,000.

SULZER BROTHERS (LONDON), Ltd., and Crompton Parkinson, Ltd., have received orders for the oil engine and electric transmission equipment for 350 b.h.p. diesel-electric shunting locomotives, for Renfe (Spanish National Railways). Of the twenty diesel engines required, sixteen are to be supplied by Sulzer Brothers (London), Ltd., and built by Vickers-Armstrongs, Ltd., at Barrow. The remaining engines are to be built in Spain at Barcelona and Bilbao. Crompton Parkinson, Ltd., is to supply the whole of the electrical equipment.

WILLIAM CORY AND SON, Ltd., have ordered from the Burntisland Shipbuilding Company, Ltd., a self-trimming collier of 4600 tons deadweight. The ship is to be built by Hall, Russell and Co., Ltd., and the triple-expansion steam engines will be supplied by the North-Eastern Marine Engineering Company (1938), Ltd. The Burntisland Shipbuilding Company, Ltd., are to build, for the same owners, a self-trimming collier of 2700 tons deadweight, having diesel engines of 1050 b.h.p. constructed by British Polar Engines, Ltd.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

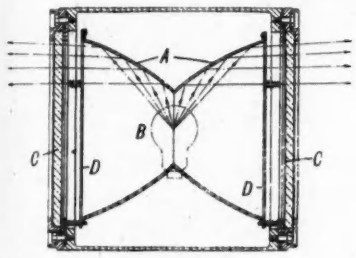
Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

ELECTRICAL ENGINEERING

650,034. April 24, 1947.—A New or Improved Light Beam Projector, Clarke, Chapman and Co., Ltd., of Victoria Works, Gateshead-on-Tyne; and William Armstrong Woodeson, of the same address.

This invention relates to light beam projectors wherein rays from an electric light source are received by a reflector such as to produce a beam for illumination purposes where glare is objectionable. The projector is adapted to produce effective illumination of concentrated nature at one and the same time in regions such as may exist in mines. The accompanying drawings show a side elevation of part of a flameproof unit

Two short focus parabolic reflectors *A A* are arranged back to back. The optical centre *B* of any suitable



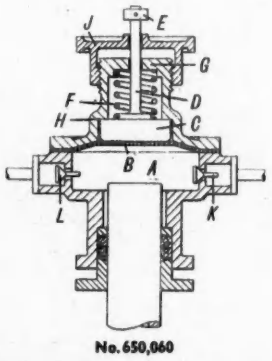
No. 650,034

standard type of incandescent lamp is arranged at the common focus of the two reflectors. The lamp and its holder are supported in any convenient way inside the main body of the unit. Leads entering by a flameproof cable connection box pass through insulated terminals to the lamp holder in the body. The armoured front glasses *C* are each cemented in a ring and sealed by a keeper ring in the housing. The whole front is then screwed on to the main body. The reflectors are supported each by a ring *D*, capable of being adjusted so that each reflector can be displaced from the true axial position. By this adjustment the resultant light beams can be inclined to suit the light distribution required as, for instance, may be necessary if the unit is set at or near a road curve or bottom of a rise in the ground in a mine. An alternative is shown in which a fluorescent tube is employed as a source of light instead of an ordinary incandescent lamp.—*February* 14, 1951.

PUMPING MACHINERY

650,060. January 19, 1948.—Improvements in Reciprocating Plunger Pumps, William Paterson, of Windsor House, Kingsway, London, W.C.2.

The object of the invention is to provide a variable delivery pump with a fixed stroke and running at a constant speed. The accompanying drawing illustrates the position of the parts during the discharge stroke of the pump. The pumping chamber *A* has on one side a diaphragm *B* attached to and



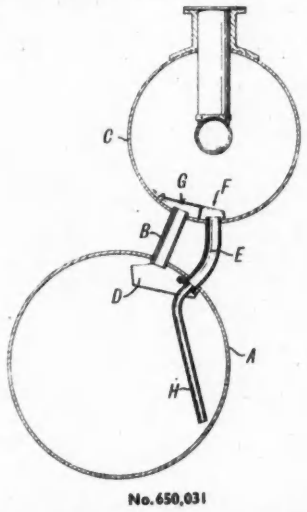
No. 650,060

movable with a support member *C* having an extended spindle *D* fitted with a collar *E*. A light spring *F* is interposed between the supporting member and an abutment *G*. The movement of the support member is limited in one direction by the abutment *H* and in the other direction by the collar *E* contacting a screwed cap *J*, the position of which determines the movement of the supporting member and the diaphragm. During the pressure stroke of the pump the inlet valve *K* is closed and the discharge valve *L* open and the supporting member *C* is forced up against the abutment. On the suction stroke the diaphragm is bulged inwards by the slight pressure of the spring until its further movement is prevented by the collar contacting the cap, the inlet valve being open and the discharge valve closed by the pressure on the discharge side of the pump. The volume discharged during the fixed stroke of the plunger can be adjusted from zero to full displacement by adjustment of the screwed cap. In an alternative arrangement described in the specification the movement of the diaphragm in one direction is limited by a perforated grid.—*February* 14, 1951.

STEAM GENERATORS

650,031. February 28, 1947.—Improvements in or relating to Steam Generators, Anglo-Iranian Oil Company, Ltd., of Britannic House, Finsbury Circus, London, E.C.2; and Sydney Rupert Dight, Engineer Rear-Admiral, C.B.E., of 3, Constable Close, London, N.W.11.

The invention provides a method of removing steam from a steam generator. It dispenses with the need for "dry pipes" or internal box baffle separators and by means of it steam may be recovered in a much drier state than heretofore. In the construction illustrated a steam and water drum *A* is connected by means of an outlet pipe or pipes *B* to a steam receiver drum *C*. The pipe *B* is connected to the drum *A* at a position near the top, the steam passing out around a baffle or deflector plate *D* and into the receiver drum *C*. A drain pipe or pipes *E* is provided so that particles of



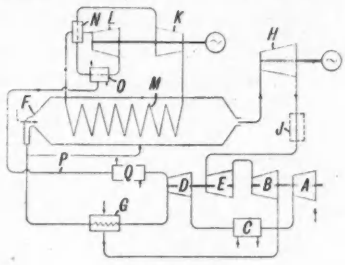
No. 650,031

moisture thrown out of suspension may return to the water space in the drum *A*. To cover the inlet of the pipe *B* into the steam receiver drum, a baffle plate *F* is provided along the length of the inner wall of the receiver drum to deflect the steam laterally. The steam inlet tube is enclosed by the baffle, leaving the drain pipe or pipes *E* unobstructed. The substantially dry steam from the drum *A* enters the receiver drum at an angle, and particles of moisture still retained in the steam are thrown out of suspension. These particles of moisture drain back into the water space in the drum *A* by way of a drain pipe *E* and an extension *H* of reduced cross section, which delivers the particles to a point near the bottom of the drum. —*February* 14, 1951.

GAS TURBINES

650,235. October 13, 1948.—Improvements relating to Gas Turbine Power Plants, Karl Baumann, of Fairgreen, Clamhunger Lane, Mere, Knutsford, and Metropolitan-Vickers Electrical Company, Ltd., of St. Paul's Corner, 1–3, St. Paul's Churchyard, London, E.C.4.

According to this invention an improved arrangement of gas turbine power plant is provided, in which a closed cycle air heating system is associated with an open cycle gas turbine system, both systems supplying working medium for the delivery of useful power. The working pressure in the air system is maintained by a connection with the discharge from one or more air compressors delivering air to the combustion chamber of the system. A first-stage open-cycle air compressor *A* driven by a low-pressure open-cycle gas turbine *B* and supplied with atmospheric air feeds compressed air through an intercooler *C* to a second-stage, open-cycle air compressor *D* driven by an intermediate pressure gas turbine *E*. Part of the output from the compressor is conducted through a branch connection to a combustion chamber *F* by way of a heat exchanger *G* in which it gains heat from the gases exhausting from the turbine *B* before they are discharged to atmosphere. Fuel is injected into the chamber and combustion takes place at high pressure. The combustion gases contain an excess of air over that required for combustion. On leaving chamber *F* the gases are expanded in a high-pressure power generating gas turbine *H*, coupled to the load, and after reheating by combustion in a secondary combustion chamber *J*, in which the necessary fuel is injected, are again



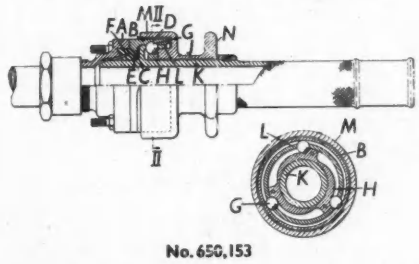
No. 650,235

expanded in the intermediate and low-pressure turbines *E* and *B*, whence they are discharged to atmosphere after cooling in the heat exchanger *G*. At *K* is indicated an air turbine coupled also to the load and at *L* an air compressor driven by the turbine, the turbine and compressor being arranged to operate on a closed air cycle. The circuit includes a convection heater *M* in thermal association with the combustion chamber *F*. After expansion in the turbine *K* the air passes through a heat regenerator *N* to a water-cooled air cooler *O*, in which it is cooled to a temperature slightly higher than the temperature of the water used for cooling purposes. From the air cooler *O* the air, after compression in the closed-circuit compressor *L*, passes through the heat regenerator *N* in which heat is absorbed from the expanded air discharged from the air turbine *K* and back into the air heater *M*. The working pressure in the closed air cycle system thus constituted is maintained by a supply of air taken through the branch connection *P* from the discharge of the open-cycle compressor *D* by way of a water-cooled air cooler *Q* to the air cooler *O* located in the closed-circuit compressor inlet conduit. By reducing the fuel supply to the combustion chamber in accordance with the load, the output of the turbines driving the compressors *A* and *D* is reduced, with the result that the pressure at the discharge of the compressor *D* and the quantity of air circulated through the combustion system are also reduced. The closed-cycle system pressure level will also be reduced in accordance with the load whilst still maintaining substantially the pressure ratio thus to enable good partial load efficiencies to be maintained throughout the range of loading.—*February* 21, 1951.

TUBE AND PIPE COUPLINGS

650,153. September 16, 1948.—Improvements in or relating to Readily Detachable Couplings, Westland Aircraft, Ltd., of Yeovil, Somerset; and Roy Wilson Gray and John Norman Stone, of the company's address.

This invention relates to readily detachable couplings for pipes of the spigot and socket type. The drawings show a sectional elevation of the



No. 650,153

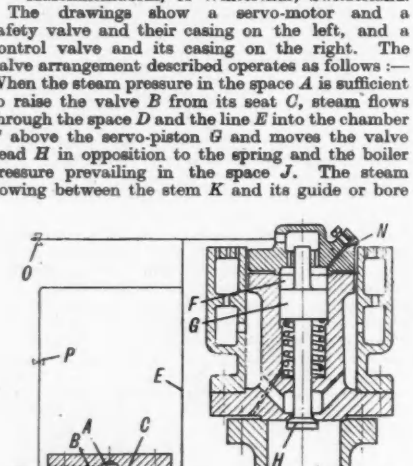
coupling and a vertical sectional view on *II—II*. There are two members attached to the ends of the pipes to be coupled. One of these, a socket member *A*, has an annular ring *B* with a flange *C* at one end. The ring *B* has an internal annular cavity *D* of semi-circular section, and in the flange is a similar cavity *E* in the outer face. This cavity houses part of a self-sealing cup washer *F* fitted in a groove in the socket *A*, whilst the cavity *D* accommodates part of each of a series of

balls *G*, which are thrust radially outwards into the cavity by a partially rotatable cam ring *H* secured to a sleeve *J* carried on the other member *K* of the coupling when in operative position. The balls are located in holes formed in a ring member *L* integral with the coupling member *K*. An annular ring *M* forms part of the hand-operable sleeve *J* rigid with the cam member. The sleeve is furnished with a hand wheel grip *N*. The sleeve is axially located on the member by a ring and a grub screw. In operation, in order to bring the parted coupling into its operative position, the end of the spigot member *K* is inserted through the ring *B*, flange *C* and sealing washer *F* to the full extent. The cam member *H* is then partially rotated and the balls are thrust outwards radially into engagement with the cavity *D*, thus locking together the two coupling members. Unlocking of the coupling is effected by a reverse movement. The cam surfaces are such that there is no tendency for the coupling to unlock under pressure.—*February* 14, 1951.

MISCELLANEOUS

650,035. May 27, 1947.—Improved Control Valve for Operating a Boiler Safety Valve, The Schweizerische Lokomotiv- und Maschinenfabrik, of Winterthur, Switzerland.

The drawings show a servo-motor and a safety valve and their casing on the left, and a control valve and its casing on the right. The valve arrangement described operates as follows:—When the steam pressure in the space *A* is sufficient to raise the valve *B* from its seat *C*, steam flows through the space *D* and the line *E* into the chamber *F* above the servo-piston *G* and moves the valve head *H* in opposition to the spring and the boiler pressure prevailing in the space *J*. The steam flowing between the stem *K* and its guide or bore



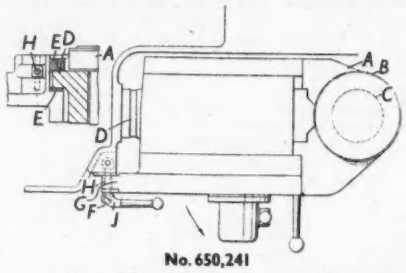
No. 650,035

into the space *L* exerts an upward pressure on the control valve *B*, which pressure may be regulated by means of the screw *M*. Owing to this counter-pressure the valve *B* is closed again by the spring when the boiler pressure has dropped by a relatively small amount. When such a drop in pressure occurs, the supply of steam to the chamber *F* is cut off and the steam contained therein escapes to the atmosphere through the throttled bore *N*, thus permitting the piston to be urged upwards by the spring and the head to be closed on its seat. By blowing off steam from the chamber *F* through the line connected through the blow-off *O* with the atmosphere, the safety valve may be closed when desired. By letting steam flow into the chamber *F*, by way of the line and the by-pass valve *P*, the safety valve may be opened when desired.—*February* 14, 1951.

MACHINE TOOLS

650,241. October 13, 1948.—Improvements in or relating to Gear-Shaping Machines, Drummond Brothers, Ltd., of Ryde's Hill, Guildford, Surrey, and Herbert Carr, of the company's address.

In the construction shown, the work table *A* is provided with an integral collar extension *B* which fits over a pillar *C* secured to the bed of the gear-shaping machine. The work table may thus be swung about the axis of the pillar and can be readily brought, by movement of the table, in the direction of the arrow from a position where a work-piece is machined to a position where it can be removed from, or mounted upon, the table. When in the working position, the end of the work table remote from the pillar is rigidly held in correct location. The end of the table is formed with a



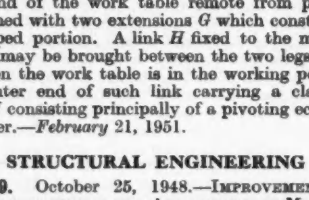
No. 650,241

tongue *D*, which engages between a pair of spaced blocks *E* rigidly supported on the machine bed. The tongue ensures that the work table is held against deflection and a clamp *F* is provided to ensure that the table is rigidly held against movement in a horizontal plane in the working position. The end of the work table remote from pillar *C* is formed with two extensions *G* which constitute a U-shaped portion. A link *H* fixed to the machine frame may be brought between the two legs of the U when the work table is in the working position, the outer end of such link carrying a clamping head *J* consisting principally of a pivoting eccentric member.—*February* 21, 1951.

STRUCTURAL ENGINEERING

650,239. October 25, 1948.—Improvements in or relating to the Attachment of Metallic Elements to Supports or other Parts, Williams and Williams, Ltd., of Reliance Works, Chester, and Jack Fox-Williams, of Victoria House, Southampton Row, London, W.C.1.

The accompanying drawing is a cross section showing the parts in position before tightening of the bolts. In the construction illustrated the glazing bar assembly is of the general kind forming the subject of British Patent No. 636,852, and comprises



No. 650,239

a girder member or bar *A* with abutments *B* projecting from opposite sides and formed with ribs *C* on which the edge portions of pieces of glass *D* bear, and a capping strip *E* which is secured to the girder by a series of screws. Formed integral with the lower edge of the girder *A* is a channel section *G* of approximately rectangular cross section with parts projecting laterally outwards from the sides of the channel as shown to form troughs in which condensate can accumulate. The sides of the channel are also provided with turned edges *H* which, in their initial state, as shown in the drawing, project in an inclined direction somewhat upwards towards the base of the channel. When the bolts *F* are tightened down they draw the edges *H* down into contact with the cross member *J*, thus distorting and flattening the edges locally.—*February* 21, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Thurs., Mar. 29th.—Luton Branch: George Hotel, George Street, Luton, "Earthing," P. W. Cave, 8 p.m.

British Iron and Steel Research Association

Wed., Mar. 28th.—Institution of Civil Engineers, Great George Street, Westminster, S.W.1, "Fundamental Studies of Corrosion and their Importance to the Engineer," U. R. Evans, 5.30 p.m.

Engineer Buyers and Representatives' Association

Fri., Mar. 30th.—Waldorf Hotel, Aldwych, London, W.C.2, annual general meeting, 6 p.m.

Illuminating Engineering Society

Thurs., Mar. 29th.—Nottingham Centre: Gas Showrooms, Parliament Street, Nottingham, "The Lighting of Lace Furnishing Machines," D. I. Griggs and F. Jamieson, 5.30 p.m.

Fri., Mar. 30th.—Birmingham Centre: Imperial Hotel, Temple Street, Birmingham, "Interesting Applications of Photometry and Colorimetry," G. F. Lothian, 6 p.m.

Incorporated Plant Engineers

Fri., Mar. 30th.—Birmingham Branch: Imperial Hotel, Temple Street, Birmingham, annual general meeting; film, "Prelude to Power," 7.30 p.m.

Institute of British Foundrymen

Sat., Mar. 24th.—Bristol and W. of England Branch: Grand Hotel, Broad Street, Bristol, annual general meeting, 3 p.m.

Wed., Mar. 28th.—Birmingham Branch: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Limitations of Die Castings," A. C. Street, 7.15 p.m.——London Branch: Waldorf Hotel, Aldwych, W.C.2, film and talk on "Brassfoundry Production Methods in the U.S.A.," F. Hudson; film, "The Brass Trail," 7.30 p.m.

Sat., Mar. 31st.—Wales and Monmouth Branch: Engineers' Institute, Cardiff, "Steel Foundry Practice," G. T. Hampton, 6 p.m.

Institute of Economic Engineering

Fri., Mar. 30th.—The Bulstrode Hotel, Hounslow, discussion Group meeting, 7 p.m.——Bolton Branch: Technical College, Bolton, "The Wider Application of Incentives," E. Hollinghurst, 7.30 p.m.

Institute of Industrial Supervisors

Fri., Mar. 30th.—Cardiff Section: Technical College, Cardiff, "Production Lay-out and Material Handling," A. J. Mansell, 7 p.m.

Institute of Road Transport Engineers

Tues., Mar. 27th.—Western Group: Grand Hotel, Bristol, "The Use of Lightweight Sandwich Materials in the Construction of Road Transport Vehicles," F. C. Lynam, 7.30 p.m.

Institution of Electrical Engineers

Fri., Mar. 30th.—N.E. Students' Section: Grey Hall, King's College, Newcastle upon Tyne, "The Reduction of Reactive Energy Losses by Means of Capacitors," G. P. Cundall, 5.30 p.m.

Institution of Engineering Inspection

Wed., Mar. 28th.—W. of Scotland Branch: Engineering Centre, 351, Sauchiehall Street, Glasgow, "Gas Turbines," P. MacGregor Ross, 7.30 p.m.

Institution of Heating and Ventilating Engineers

Tues., Mar. 27th.—Scottish Branch: Engineering Centre, 351, Sauchiehall Street, Glasgow, "Pneumatic Conveying and Dust Exhausting," 6.30 p.m.

Fri., Mar. 30th.—Manchester and District Branch: Town Hall, Manchester, "The Caterole Plant," 6.30 p.m.

Institution of Mechanical Engineers

Thurs., Mar. 29th.—N.W. Branch, Graduates' Section: Engineers' Club, Albert Square, Manchester, "Industrial Steam Turbines," D. A. White, 6.45 p.m.——Western A.D. Centre: Royal Hotel, Bristol, "The Development of the De Havilland Series of Engines for Light Aircraft," J. L. P. Brodie, 6.45 p.m.

Fri., Mar. 30th.—Storey's Gate, St. James's Park, S.W.1, annual general meeting (corporate and non-corporate members only), 5.30 p.m.

Institution of Production Engineers

Tues., Mar. 27th.—S. Wales and Monmouthshire Section: S. Wales Institute of Engineers, Park Place, Cardiff, "Defects and Developments in Deep Drawing and Pressing," J. D. Jevons, 6.45 p.m.

Wed., Mar. 28th.—Western Section: Grand Hotel, Broad Street, Bristol, annual general meeting, 7.15 p.m.

Thurs., Mar. 29th.—London Section: Royal Empire Society, Northumberland Avenue, W.C.2, "Mechanical Handling in Industry and its Influence on Costs," W. J. T. Dimmock, annual general meeting, 7 p.m.

Institution of Structural Engineers

Thurs., Mar. 29th.—11, Upper Belgrave Street, London, S.W.1, "Construction of the Royal Festival Hall," E. Roland Hole and F. C. Eales, 5.55 p.m.

Fri., Mar. 30th.—Midland Counties Branch: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Solution of the Car Parking Problem Here and in the U.S.A.," W. P. Andrews and P. G. Bowie, 6 p.m.——Wales and Monmouthshire Branch: County Buildings, Colwyn Bay, "Structural Engineering at Abbey Works," A. V. Hooker, 6 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Fri., Mar. 30th.—Mining Institute, Newcastle-upon-Tyne, "Forging Methods," J. C. Stevens, 6.15 p.m.

Royal Aeronautical Society

Thurs., Mar. 29th.—Institution of Civil Engineers, Great George Street, Westminster, S.W.1, "Some Aspects of Modern Naval Aircraft Design," D. L. Hollis Williams, 6 p.m.

Society of Engineers

Fri., Mar. 30th.—17, Victoria Street, Westminster, S.W., "Some Waterproofing Problems," I. Hopkins; "Competitive Design of Steel Structures," J. C. Maxwell Cook, 6.30 p.m.

Society of Instrument Technology

Tues., Mar. 27th.—Manson House, Portland Place, London, W.1, "Magnetic Amplifiers," D. A. J. Maddock, 7 p.m.